U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB-274 078

Inspection/Maintenance Cost-Effectiveness and Feasibility of Implementation

Environmental Protection Agency, Washington, D C

May 77

PB 274 078

INSPECTION/MAINTENANCE: COST-EFFECTIVENESS AND FEASIBILITY OF IMPLEMENTATION

E. J. Bentz, Jr., Project Director
Sandra J. Bodmer-Turner
Barry Korb
William P. White III

of

Long Range Planning Group
Office of Planning and Evaluation
U. S. Environmental Protection Agency

May 1977

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U. S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

BIBLIOGRAPHIC DATA SHEET

1. Report No.

2.

3. Recipient's Accession No.

4. Title and Subtitle
INSPECTION/MAINTENANCE: COST-EFFECTIVENESS AND
FEASIBILITY OF IMPLEMENTATION

5. Report Date
May, 1977

6.

7. Author(s) William P. White, III
Edward J. Bentz, Sandra J. Bodmer-Turner, Barry Korb,

8. Performing Organization Rept. No.

9. Performing Organization Name and Address
Long Range Planning Group
Office of Planning and Evaluation
U.S. Environmental Protection Agency

10. Project/Task/Work Unit No.

11. Contract/Grant No.

12. Sponsoring Organization Name and Address
Policy Planning Division
Office of Planning and Evaluation
EPA, 401 M St., S.W.
Washington, D.C. 20460

13. Type of Report & Period Covered

14. 400/02

15. Supplementary Notes

16. Abstracts

This study looks at the potential reductions in hydrocarbons (HC) achievable through I/M of cars without catalytic converters. Reductions of 8% to 30 or 40% may be possible. The report is based on case studies of I/M programs being implemented in several states. The study identifies and analyzes factors which affect the cost and effectiveness of an I/M program. Effectiveness will be influenced by: the type of I/M test, frequency of inspection, the failure rate of inspected cars, the extent of deterioration of the emission rate between inspection, the quality of auto repair work, tampering cost varies with the type of tests, and the organizational structure, i.e., private or government run. The report also discusses certain critical factors which may determine a program's viability: Whether EPA has the authority to require →

continued on separate sheet

17. Key Words and Document Analysis. 17a. Descriptors

Hydrocarbon
Oxidants
Auto emissions
Inspection
Maintenance
Precatalyst Vehicles
Public acceptance
Deterioration
Tampering
Inspection/Maintenance Cycles

17b. Identifiers/Open-Ended Terms

Air Pollution
Transportation Policy
State Implementation Plans
State programs
Automobile Engines
Ambient Air Quality

17c. COSATI Field/Group

18. Availability Statement
Release Unlimited

1<

19. Security Class (This Report)
UNCLASSIFIED

20. Security Class (This Page)
UNCLASSIFIED

21. No. of Pages
121

22. Price PCA06
MFA01

continuation sheet for abstract # 16

INSPECTION/MAINTENANCE: COST-EFFECTIVENESS AND FEASIBILITY OF IMPLEMENTATION

Author(s): William P. White, III, Edward J. Bentz, Sandra J. Bodmer-Turner,
Barry Korb

I/M programs; the lack of technical data on auto performance and emissions; the public's willingness to accept the program; and state government's capacity to pay for implementating the program. Public acceptance is considered a major stumbling block. The report notes other factors which will affect the impact of an I/M program on air quality.

Abstract

Our cost-effectiveness analyses suggest that mandatory inspection and maintenance of light duty vehicles can reduce their tailpipe HC emissions by at least 8 - 15%; for controlled precatalyst vehicles a best estimate is 14 - 27%. Costs, and in particular transaction costs, can be kept to a minimum by use of a fee-financed system of mandatory inspection. Of key concern to program success is the public acceptability. This is especially so in light of the high visibility and controversial nature of regulation of the use of the auto. High repair costs, infrequently experienced in our case study analysis, coupled with public distrust of the auto repair industry pose serious challenges to successful implementation. State owned and operated facilities, although affording the most satisfactory form of consumer protection, suffer from chronic long term State budgetary restraints. In many cases, these restraints are crucial if not determining, to program inception, and continuation.

EXECUTIVE SUMMARY

This Executive Summary contains:

1. Purpose of Study
2. Approach Used in this Study
3. Effectiveness of Inspection and Maintenance - Critical Factors
4. Cost of Inspection and Maintenance - Critical Factors
5. Summary of Findings

1. Purpose:

This volume of the Cost-Effectiveness of Inspection and Maintenance (I/M) is one of several volumes of an in-house (Office of Planning and Evaluation) study on the cost-effectiveness and feasibility of implementation of several oxidant control strategies. This study focuses solely on the cost-effectiveness of I/M as a strategy for reducing hydrocarbons (HC) - leaving for another volume an assessment of the correlation between HC control and oxidant control. The results of this study will be compared with the results of other in-house studies on selected transportation control plan (TCP) measures to determine the relative cost-effectiveness and feasibility ranking of all these selected TCP measures as HC emission control strategies.

This study attempts to:

1. identify and, where sufficient data exist, quantitatively measure the critical factors that determine the cost, effectiveness, and feasibility of implementation of I/M as an HC/oxidant control strategy.

2. identify and measure the uncertainties associated with each of the critical factors identified.

2. Approach Used in this Study

The study attempts to address to the extent possible the most critical factors which could affect the effectiveness and costs (both direct and transaction costs) of an inspection/maintenance program and to quantify to the degree possible the impact of those factors. Where possible, the study also attempts to quantify the uncertainty associated with each factor.

The report is case study oriented and, for the most part, is based upon empirically observed or documented facts. Theoretical models are used to estimate cost, effectiveness and feasibility only when no experimental or operational data are presently available.

4.

In analyzing the effectiveness of I/M, we reviewed all the technical data available (which is unfortunately meager and incomplete in many areas), qualified it by the uncertainties inherent in the assumptions used to derive the data, and attempted to draw conservative, but hopefully accurate, estimates from it. We did not project any benefits, even though they might reasonably be expected, unless they were empirically documentable. EPA, in estimating SIP emission reduction credits to be given to States adopting I/M programs should probably adopt a less conservative basis for developing its effectiveness estimates.

In analyzing the costs of I/M, we spent considerable effort creating a reliable and much needed data base since actual, detailed cost data had never been thoroughly collected. We did this by going, in all cases, directly to the primary sources of such information: the State and local officials who operate such programs.

3. Main Issues Affecting Cost and Effectiveness of I/M

A. Effectiveness

After listing all of the factors which are thought to influence the effectiveness of I/M, we divided them into two groups - the factors internal to any I/M program design (such as the type of test used, the failure rate established, or the frequency of inspection required) and the factors external to any I/M program (such as the quality of the maintenance received after the car fails inspection, the effect of tampering, and the deterioration rates assumed). We found the external variables to be of considerable importance. Four external variables emerged as particularly important to I/M effectiveness:

1. the extent of deterioration between one I/M inspection and the the next (i.e., between inspection and re-inspection),
2. the average deterioration experienced over several I/M cycles,
3. the quality of inspection-mandated maintenance, and
4. tampering.

Since the major portion of research done by EPA and the States to date has focused on the initial impact of internal factors, we tried to assess whether the effectiveness of these internal factors would be overwhelmed by the uncertainties underlying assumptions made in these efforts by the external factors.

Our results indicate that for precatalyst vehicles any State-run I/M program can affect to some degree most of the significant internal and external variables given, certain budgetary, management, public acceptability, and enforcement constraints. The choice of I/M program's internal facotrs such as flunk rate, frequency of inspection and type of inspection test can be modified as required within these constraints with, for well designed programs, a resulting minimal range of I/M effectiveness in reducing HC from 8% to 15%. Tampering could be abated with effectively enforced anti-tampering laws. However, if after inspection (and repair) tampering occured on 20 - 30% of all vehicles, I/M could be reduced to 0% effectiveness in reducing HC emissions. The potential for this tampering appears to be greatest with respect to catalyst vehicles. The quality of inspection-mandated maintenance seems likely to be improved over time particularly with a carefully administered mechanic training program. The difference between an I/M program based upon specially trained vs. untrained mechanics could be as much as 3-6% in terms of effectiveness in reducing HC. In addition, it appears likely that there will be an additional benefit of 3-6% in I/M effectiveness for HC because of the slower than linear deterioration rates found for vehicles after maintenance.

The one factor over which State I/M programs have no control but which does affect the level of effectiveness of an I/M program is the average deterioration rates. With I/M, limited data does exist on the deterioration rates of autos over one inspection and maintenance cycle, but little is known about the average deterioration over successive cylces. Depending upon the data yet to be developed about deterioration rates, the effectiveness of I/M in reducing HC for pre-catalyst vehicles could increase by 40-50%, i.e., to a maximum effectiveness of approximately 40% averaged over the full life of an I/M program. There is, however, as of now, an adequate basis on which to assume that this potential will be achieved.

The above results are valid for pre-catalyst-equipped vehicles only. There are little or no data available to date to indicate whether I/M will be any more or less successful as a measure to reduce HC pollution from catalyst-equipped vehicles. Initial indications are that it will be slightly more effective (in the percentage terms used above). However, the big uncertainty remains: what is the effect of repeated cycles? And a new uncertainty-catalyst failure rates is introduced. In addition, it is probable that over time design improvements will reduce the potential effectiveness of I/M programs. It is recommended that, for now, estimates for pre-catalyst vehicles continue to be used.

B. Cost/Feasibility

Although effectiveness is a key criterion for determining the appropriate role of a control strategy, cost is rapidly becoming a crucial, if not determining, constraint. This is particularly due to the highly visible, highly controversial nature of regulation of the automobile.

As indicated in Figure ES 1, direct program costs involve start-up (capital and administrative) and recurring (salaries, leasing and "other") expenditures. These cost vary considerably, ranging from roughly $3 to $8 vehicle.* These variations are due to four principal program characteristics:

1. Organizational Structure — centralized or decentralized; publicly or privately operated;
2. Test Type — emissions only, or emissions and safety;
3. Test Mode — idle or loaded; and
4. Geographic Location — Northeast, North Central, South West.

Our data suggest that centralized systems are less costly overall than decentralized systems (where certain garages are certified to perform the inspection), although initially the centralized inspection system involves slightly higher start-up costs. The cost differences between publicly and privately operated systems are addressed below. The cost differences between the various types and modes of tests clearly favor the emissions-only idle test (see Figure ES 1,). The cost differences by Region indicate that I/M programs in the Northeast and North Central Regions of the country will tend to cost more due to higher land, building and labor costs than comparable programs in the South and West. A program in New York, for example, might cost as much as $20 per vehicle.

In addressing the feasibility of establishing a particular I/M program, two important issues arise in relation to costs:

1. whether the State or local government has sufficient financial resources to meet the costs, and
2. whether the fee charged for each inspection to cover the direct program costs is set at a level that is acceptable to the public.

To date, existing programs have experienced no major difficulties in financing despite the fact that all existing systems are centralized, requiring large initial capital outlays, and all but one are publicly operated, requiring capital outlays from decreasing capital availability in the public sector continues, centralized public systems may become difficult to implement, resulting in a push toward private sector operation.

---

* Assuming that start-up costs are recouped over a five-year period and that per lane throughput is 32,000 LDV's/year.

Since private decentralized systems pose considerable consumer protection problems, especially when operated by the auto service industry, private centralized systems are the most promising structure for future program implementation.*

The financial viability of I/M despite its relatively expensive price tag is due to the fact that I/M is a fee-financed program. State and local governments are likely to have sufficient financial resources for I/M implementation because the program has the potential to create a source of revenue sufficient to underwrite it.

This brings us back to the second cost issue: whether the fee necessary to finance the inspection is publicly acceptable. The scanty and dated information available on this question indicates that an acceptable maximum fee in most States is $5., putting almost all existing programs on the edge of public acceptability. New Jersey State legislators have judged that a fee of approximately $2.50 to cover most of its I/M program's operating costs is publicly acceptable.

An additional cost of I/M programs is the cost for inspection-mandated repairs. These costs are paid out-of-pocket by owners of vehicles that fail the inspection; in existing programs this 18-47% of all affected vehicle owners. Although information is available on the amount of these costs - on the average $16. to $32.50 with two-thirds of all flunked vehicle owners paying less than this average -- no information is available on the public's response to these costs. Using figures for the average cost of an annual tune-up ($33-40 for tune-up including horn), one may suggest that I/M-mandated repair costs are generally publicly acceptable: only 24% of all vehicle owners pay more than $100. However, I/M repairs may be perceived quite differently from a tune-up due to their mandatory nature and intangible benefits. Another cause for this different view is reflected in the City of Chicago's stated reason for continuing a non-mandatory program: the citizens of Chicago should not have to pay for what the auto manufacturers are doing or are not doing right. Implementation of Section 207(b) of the CAA would alleviate their problem and put the responsiblity for the cost of emissions repairs on the automotive industry, presumably improving the feasibility of implementing I/M. (Once again, quality control in engineering design may significantly decrease deterioration).

---

* Arizona is the only existing example of a private centralized system.

Critical Areas of Uncertainty

Critical areas of uncertainty that affect I/M are:

1. **Legal Authority:**

There is no clear undisputed statutory authority for I/M. At present there are five different decisions in five different Courts of Appeal on I/M (see Chapter 2, and Appendix R) with appeals to the Supreme Court already filed. This uncertainty dampens the enthusiasm of States considering prospective I/M Programs.

2. **Automotive Research Knowledge:**

Automotive research knowledge is very meager, and incomplete. For many critical questions such as the shape of the vehicle deterioration curve: without I/M, between I/M program cycles, and after initial I/M progam, there is an insufficient amount of reliable, uniform information. The literature abounds with garden variety conjectures and tidbits of poorly substantiated or statistically inconsequential information. Such technical uncertainties generate enormous amounts of uncertainty for States considering prospective I/M programs.

3. **Public Acceptability of Program:**

There is much uncertainty surrounding the public acceptance of any program that regulates the use of automobiles. The track record for existing I/M programs has been one of a mixed reception. Until a clearer determination is made of what factors contribute to public acceptance, program marketing efforts and hence successful implementation will be severely hampered.

4. **State Budget Authority:**

State budget authority in many States is presently being strained by inflation increasing expenses, and declining revenues. Long term, fixed recurring expenses (such as pensions, fringe benefits) are examples of those highly visible public expenses common to some I/M programs. In addition, most States' capital budgets are augmented by bond issues, and subject to public referendums. In light of the issues raised in (3) above concerning uncertainty in public acceptance, additional uncertainty is generated among States considering I/M programs. Publicly operated I/M programs, by expending public sector employment, can further strain these resources in both the short and long term. If the short term public expenditures for salaries are increased, over the longer term obligations for civil servant benefits (eg. pensions) are also increased.

Summary

The cost-effectiveness of I/M as a measure for reducing HC varies from locality to locality and program to program. The desirability of a program in any given area will depend on part on the relative cost-effectiveness of I/M compared to the cost-effectiveness of other measures.

1. Effectiveness

I/M for controlled pre-catalyst vehicles appears to have a minimal effectiveness range of from 8% to 15% in reducing HC, depending on the choice of internal variables and assuming that tampering is kept to reasonable limits. A best estimate is 14% to 27%. Its effectiveness could range as high as 30-40% if all the most optimistic assumptions about deterioration rates prove true; however, this is unlikely to be the case.

2. Cost/Feasibility

Relative to direct State and local expenditure for air quality management, I/M can be an extremely expensive program. However, since I/M has the potential to be self-financing, cost per se presents no major obstacle to implementation. What may pose a serious block is the vehicle-owning public's response to the program. Not only does I/M require that the public perform a new task, but it also requires that the public pay to perform this task (via inspection fees and repair bills) thereby adding insult to injury. This adds to the costs and complexities of vehicle ownership and operation. Consequently in many areas of the nation where the automobile is an integral part of the dominant life style, I/M can be expected to encounter serious resistence. Unless a much better public marketing program is developed, and a more flexible implementation program initiated, I/M may encounter some serious problems.

Recent Data

The data from California's new program suggest that the ultimate effectiveness of I/M may not yet be realized. There the loaded test is less cost-effective for HC and CO than the idle test (even the trained mechanics are to date apparently unable to make use of the extra information provided by the loaded test). However, the loaded test has the potential for cost-effectively controlling an additional pollutant (NOx) which is simply not technically possible with the idle test.

The total cost-effectiveness of I/M for controlling CO and NOx as well as HC must, unfortunately, be the subject of another report. The intent of this volume is to quantify the cost-effectiveness of I/M as a measure for reducing HC, and ultimately oxidant. Conclusions about the relative cost-effectiveness of I/M as compared to carpools, vanpools and preferential lanes are drawn in Volume I of this study.

TABLE OF CONTENTS

Preface

Abstract

Executive Summary

Table of Contents

List of Figures

List of Tables

PART A: EFFECTIVENESS

- I. Introduction
  - A. The Role of I/M
  - B. Approach to Analysis
  - C. Data Base: Strengths and Weaknesses
- II. Model of An I/M Program's Effectiveness
  - A. Introduction
  - B. A Single I/M Cycle
  - C. Repeated I/M Cycles
- III. Critical Factors
  - A. Emissions in the Absence of I/M
  - B. Single Cycle I/M Effectiveness
    - 1. Initial Emissions Reductions
    - 2. Emissions Deterioration after Maintenance
  - C. Repeated Cycle Effectiveness
- IV. The Special Case of Catalyst-Equipped Vehicles
- V. Factors Outside of the Model

Bibliography to Part A

PART B: COST AND FEASIBILITY

- VI. Introduction
  - A. The Issues
  - B. The Data Base: Strengths and Weaknesses
- VII. Organizational Structure
  - A. Consumer Protection
  - B. Convenience
  - C. Start-up Time

VIII. Costs Associated with I/M Implementation
  - A. Introduction
  - B. Start-up Costs
  - C. Recurring Costs
  - D. Repair Costs
  - E. Executive Summary

IX. Feasibility of Implementing I/M
  - A. Introduction
  - A. Vehicle Owner Marketability
  - B. Legal and Institutional Framework

Bibliography to Part B

APPENDICIES

A. Existing State Inspection/Maintenance Programs
  1. Maricopa and Pima Counties, Arizona
  2. Cincinnati and Norwood, Ohio
  3. Portland, Oregon
  4. Chicago, Illinois
  5. State of New Jersey
  6. Riverside, California

B. I/M Cost Estimates
  1. Capital Cost Estimates for Publicly Owned and Operated Systems
  2. Capital Cost Estimates for Private Garage Systems
  3. Recurring Cost Estimates for Publicly Owned and Operated Systems
  4. Recurring Cost Estimates for Private Garage Systems

C. EPA's Authority to Implement I/M: Background and Summaries of Significant Decisions

LIST OF FIGURES

Part A: Fig. 1 - Flow of a Single I/M Cycle
Fig. 2 - Model of a Single Inspection/Maintenance Cycle
Fig. 3 - Model of Emissions over Several I/M Cycles
Fig. 4 Model of the Potential of Repeated I/M Cycles
Fig. 5 - Results of Alternative Types of Inspections
Fig. 6 - Impact of Post-Maintenance Deterioration on I/M Effectiveness over a Single Cycle
Fig. 7 - I/M Program Effectiveness for Several Scenarios

LIST OF TABLES

ES 1 - Direct Program Costs

Part A:

Table 1 - Comparison of Design HC Emissions Standards with Actual In-Use Emissions for Selected Classes of Vehicles
Table 2 - Sources of Empirical Data on I/M Effectiveness
Table 3 - Factors Influencing the Effectiveness of I/M Programs
Table 4 - Initial Effect of Maintenance on Emissions from In-Use Vehicles
Table 5 - Initial HC Emission Reductions by Failure Rate for Controlled, Precatalyst Vehicles
Table 6 - HC Deterioration Relative to Baseline Emissions
Table 7 - Deterioration of Vehicle Emissions After Testing in a Simulated I/M Program

Part B:

Table 8 - Capital Costs for Existing Programs
Table 9 - Organizational Structures: Advantages and Disadvantages
Table 10 - Comparison of Study Estimates of Start-Up and Recurring Expenditures for Decentralized and Centralized Systems
Table 11 - Recurring Costs for Existing Programs
Table 12 - Repair Costs for Existing Programs
Table 13 - Total Program Costs and Revenues for Three Existing Programs
Table 14 - Status of Periodic Motor Vehicle Inspection in States with SIP's Requiring I/M
Table 15- Legislative History

PART A: EFFECTIVENESS

I. INTRODUCTION

A. The Role of Inspection/Maintenance(I/M)

EPA is interested in I/M programs because many Air Quality Control Regions (AQCRs) need to further reduce emissions of hydrocarbons (HC) (and carbon monoxide (CO)) in order to meet National Ambient Air Quality Standards (NAAQS). Emissions of HC from light duty motor vehicles, about 50% of total nationwide HC emissions in 1970, can be reduced either technologically, by reducing emissions per vehicle mile driven, or by reducing the total number of trips or miles light duty motor vehicles drive. a/ I/M aims at reducing emissions per vehicle mile driven.

Available data indicate that, at least at the end of the assembly line, most vehicles are capable of meeting the emission standards for which they were designed. However, unless well maintained throughout their useful lives, these vehicles eventually emit excessive amounts of pollutants, failing to realize the full emission reduction gains made possible by improved engine design. b/ (See Table 1.) Realizing the emissions reduction potential obtainable by improved maintenance is doubly important because original air quality planning (i.e., SIP development) was based on the assumption that emissions would be lower than the levels that are now being encountered. Consequently, the level of emissions reduction that must be achieved by local regulations is greater than was originally anticipated.

Empirical data show that, in principle, a significant reduction could be achieved in HC emissions per vehicle mile driven if increased maintenance were performed on in-use vehicles. Since attainment of an improved quality and quantity of emissions-related maintenance is precisely what I/M programs are designed to achieve, inspection/maintenance programs appears to be a promising control strategy. Consequently, they have assumed an increasingly important role in EPA's approach to air quality management.

B. Approach to Analysis

While recognizing the importance of I/M as a CO-reducing tool this report, one chapter in a larger study on oxidant control, focusses solely on I/M's emissions reduction potential for hydrocarbons. After

---

a/ This involves redistributing or reducing travel demand. The elasticity of demand for transportation services is dependent on many factors: price, convenience, time, etc. This demand may be affected by altering any of these factors.

b/ Even well maintained vehicles do not necessarily meet emission design standards throughout their useful lives. However, poorly maintained vehicles have been found to have emission levels even further from their design standards.

TABLE 1

COMPARISON OF DESIGN HC EMISSION STANDARDS WITH ACTUAL IN-USE EMISSIONS FOR SELECTED CLASSES OF VEHICLES 1/

Vehicle Class	HC Design Standard (gm/mi) 2/	Means (S.D.) of Actual HC Emissions (gm/mi) 3/	Percent Difference
1971 Model Year Cars (av. mileage-37,400)	4.6	4.85 (2.89)	+5.4% 4/
1972 Model Year Cars (av. mileage-28,700)	3.4	4.69 (2.27)	+38% 4/
1973 Model Year Cars (av. mileage-18,100)	3.4	4.06 (2.07)	+19% 4/

1/ Based on 1973 Emissions Factor Program as reported in Ref. 1 (p. 34) and standards as summarized in Ref. 5 (1972 FTP employed).

2/ Manufacturers are required to design and produce vehicles which, if they are properly maintained and used, will be capable of meeting these standards for five years or 50,000 miles.

3/ Arithmetic means.

4/ Statistically significant at the 95% confidence level.

16.

reviewing the information presently available a/ on the effectiveness of inspection/maintenance in reducing HC emissions from light duty vehicles, factors that influence the effectiveness of any I/M program were identified and categorized as internal variables (program design features) or external variables (factors largely independent of program design). (See Table 3.) Since considerable research and analysis has already been done by the Agency on the effects of variations in internal factors, a decision was made to focus this report primarily on factors external to any particular program's design. This choice was also made because of the relative size of the uncertainties generated by these two different classes of variables. External variables seemed to create much greater uncertainty in effectiveness estimates.

In further explorations of the available literature, four of these external variables emerged as particularly important to I/M effectiveness:

1. the extent of deterioration between one I/M inspection and the next,
2. the quality of the inspection-mandated maintenance,
3. tampering, and
4. the average deterioration experienced over several I/M cycles.

The report proceeds with a brief discription of a simple I/M effectiveness model, followed by a discussion of I/M program effectiveness as a function of the internal and external variables. Emphasis in the discussion is given to the four external variables noted above. Estimates of the impact of these four key variables on program effectiveness are illustrated for controlled, precatalyst vehicles b/ with the aid of our I/M effectiveness model. The report concludes with a discussion of I/M effectiveness for catalyst-equipped vehicles, and some observations on factors outside of the model.

C. Data Base - Strengths and Weaknesses

Choice of Measurement System

Emissions from light duty vehicles have been, and continue to be, measured by a variety of tests (e.g., idle, key mode, FTP). Unfortunately, these differences in testing methodologies produce results which are in most cases not comparable due to a lack of correlation between testing results. Hopefully, data from EPA's short-cycle test program will eventually alleviate part of this problem. c/ At

---

a/ This report is based on information available in the spring of 1976.
b/ Currently two-thirds of all in-use vehicles. Ref. 29.
c/ Current indications are that relative changes in emission levels may be more accurately measurable by some short tests than are absolute levels.

present the most acceptable test methodology for measuring effectiveness is the 1975 version of EPA's (Urban Cycle) Federal Test Procedure (FTP). Data taken using EPA's 1972 FTP can be converted so as to be equivalent to data based on the 1975 FTP.[a] Thus, data from both these tests provide acceptable measurements.

There are several reasons why we consider the '75 FTP to be a sound methodology for measuring mobile source emissions:

1. it measures emissions from vehicles over a simulated driving cycle [b] and, therefore, can be assumed to approximate actual in-use emissions;
2. available evidence indicates that it is a reasonably reliable test; [c] and
3. it is the test used in certifying light duty vehicles and so represents the "language" of the baseline standard to which in-use vehicle performance must be compared.
4. it measures emissions in terms of their total mass (in gms/mile) and, hence, is directly relatable to ambient levels whereas idle tests only measure the relative concentrations of pollutants in the exhaust gas.

---

[a] The 1972 test procedure produces HC emission levels approximately 10% greater than the 1975 procedure for precatalyst vehicles and approximately 33% greater for catalyst equipped vehicles.

[b] In fact, this is still only an approximation, since in many urban areas actual driving cycles are substantially different from the FTP's simulated cycle. Major differences include average speed, portion of mileage driven in a "cold" operating condition, and average ambient temperature. Supplement 5 of EPA's Emission Factor Handbook contains estimates as to the effects of these variables. These factors can easily alter baseline emissions levels by 50%, and consequently, have an effect on the relative change in emissions achievable by an I/M program. However, looking at emissions from a national perspective, the 1975 FTP is probably reasonable. Analyses of I/M effectiveness in specific localities would do well, where possible, to take into account the differences in driving cycles and ambient temperatures.

[c] However, because of its complexity and the time it takes to administer the test there are problems in collecting extremely high quality data. Thus, data from EPA's In-Use Compliance Program (IUCP), although considered to be some of the best FTP based surveillance data available, was still judged by EPA's Mobile Source Enforcement Division to be inadequate for use in court.

Data Availability

Selection of the 1975 FTP as the basis for analysis means that much of the available data, which use other testing regimes, can only be used for qualitative, as opposed to quantitative, information. In addition, while significant and increasing quantities of data on vehicular emissions are gradually becoming available, it will be seen that, for several of the factors that can have major impacts on I/M effectiveness, there is a general paucity of appropriate data.

Prime sources of data include:

- EPA's Emissions Factor Program (EFP),
- EPA's In-Use compliance Program (IUCP),
- Special tampering studies, and
- Special studies of I/M emission reductions.

The EFP provides data on emissions deterioration with time and mileage from vehicles which are subject to "normal" levels of in-use maintenance. There are presently four data sets, providing four points and covering 3 years. [a] The data were measured using the 1972 or 1975 FTP. These data provide the basis for estimates of deterioration in the absence of I/M.

The IUCP provides estimates on emissions levels achievable by well maintained vehicles. Under this program vehicles were tuned to manufacturer's specifications prior to having their emission levels tested. This program, after 2 years of operation, has been discontinued. Essentially, the IUCP provides information on potential emissions given "proper" maintenance.

Special tampering studies have been done for New Jersey, Portland, Oregon and Washington, D. C. Unfortunately, none of these studies has examined post-inspection/reinspection tampering.

Special studies of I/M emissions reductions have been performed for EPA and the State of California. They provide FTP data on initial, maintenance-induced emissions reductions as a function of failure criteria, control technology, maintenance level and test method. In addition, the Office of Mobile Source Air Pollution Control, the Office of Transportation and Land Use Planning, and the Mobile Source Enforcement Division have all made efforts to model I/M effectiveness. [b] These models shed light on the interaction of certain critical factors and the impact of various assumptions on I/M program effectiveness.

---

[a] The fourth data set has not, however, been fully analyzed as of the date of this report.

[b] See Ref. 7, 35, and 36.

Nonetheless, FTP-based data on tampering, maintenance quality, deterioration after initial maintenance and particularly deterioration over several cycles, are scarce. Empirical data on emissions reductions obtainable from catalyst equipped vehicles as a function of internal I/M program variables is also very limited. Table 2 summarizes the information available for judging the impact of these and several other factors thought to have significant influence on potential I/M effectiveness.

TABLE 2
SOURCES OF EMPIRICAL DATA ON I/M EFFECTIVENESS

		Comments	
Factor	Source of Data	Controlled-Precatalyst	Catalyst
Emissions Deterioration in the Absence of I/M	Emission Factor Program	oGood quantitative data o Large variance in estimates o Very limited information as to shape or assymptote of deterioration curves	o Good quantative data oOnly one year's data
Initial Emissions Reductions			
Failure Rate	'72 Olsen	o Good quantitative data based on one empirical failure rule	N/A
Mechanic Training	'76 Riverside	o Partially conflicting results	N/A
Test Method	'72 Olson	o Good quantitative data	N/A
	'75 Olson	o Partially conflicting results	N/A
	'76 Riverside		N/A
Overall Initial Reduction	'76 Olson	o See above comments	oOnly one data point available
Deterioration Over One Cycle	'75 Olson	o Good quantitative data o Inconclusive results	oNo empirical data
Deterioration Over Repeated Cycles	None	o No empirical data	oNo empirical data
Tampering	N. J. D. C.	o Good quantative data o Not indicative of after maintenance tampering	oNo empirical data
	EFP	NA	oNot indicative of after maintenance tampering

a/ 1. Additional empirical studies exist - but they address themselves to factors already adequately quantified by the studies included in this table. See references or relevant discussion in text for citations.
2. Models exist to provide additional insight into the effects of and interrelationships among these variables. See References.

II. A MODEL OF AN I/M PROGRAM'S EFFECTIVENESS

A. Introduction

In performing our analysis of I/M effectiveness we constructed a simple "model" of an I/M program - essentially a sequence of graphs which represent the concepts under review. The sole purpose of the model is to facilitate discussion of the impacts of certain program variables on inspection/maintenance effectiveness estimates. This model represents a somewhat speculative sketch of the factors involved, that is, elements of the model cannot be fully supported by empirical data. This is especially true of estimates of the effects of repeated I/M cycles which have almost no empirical basis. The interactive effects of many of the factors also remain unknown.

The model does, however, serve to identify the factors that influence the effectiveness of an I/M program and to identify the direction of the influence exerted by each factor. These factors are summarized in Table 3, which lists all the relevant factors and categorizes them as either internal or external. Internal factors are those factors over which an individual I/M program has direct control (e.g., test mode, failure rate, and so on). External factors are factors that are not under the direct control of any individual program (e.g., long- and short-term deterioration rates [a]) although some of them - tampering, quality of inspection-mandated maintenance, and extra voluntary maintenance - can be influenced by the I/M program itself or by separate complementary programs.

B. A Single I/M Cycle

The essential sequence of events for a vehicle participating in an I/M program is:

1. the vehicle is brought in for an emissions test;
2. if the vehicle exceeds pre-set emission levels, it is required to undergo maintenance to reduce these excessive emission levels at least to the pre-set emissions level; and
3. the repaired vehicle is retested.

---

[a] Individual I/M programs cannot affect short and long term deterioration rates (i.e., the rates at which emissions increase after a single incident of mandated maintenance and over several inspection/maintenance cycles). However these deterioration rates may be affected by the warranty and recall provisions that may eventually be tied to I/M. Such provisions would provide automotive manufacturers with incentives to alter their design and production processess to decrease the deterioration rates of parts and systems that effect emissions. However, the anticipated impact of warranty and recall would be unlikely to occur until several years after the provisions' implementation. A similar result may occur for an individual manufacturer if his vehicles are singled out as having excessive failure rates in I/M programs.

TABLE 3

FACTORS INFLUENCING THE EFFECTIVENESS OF I/M PROGRAMS

INTERNAL FACTORS - program design

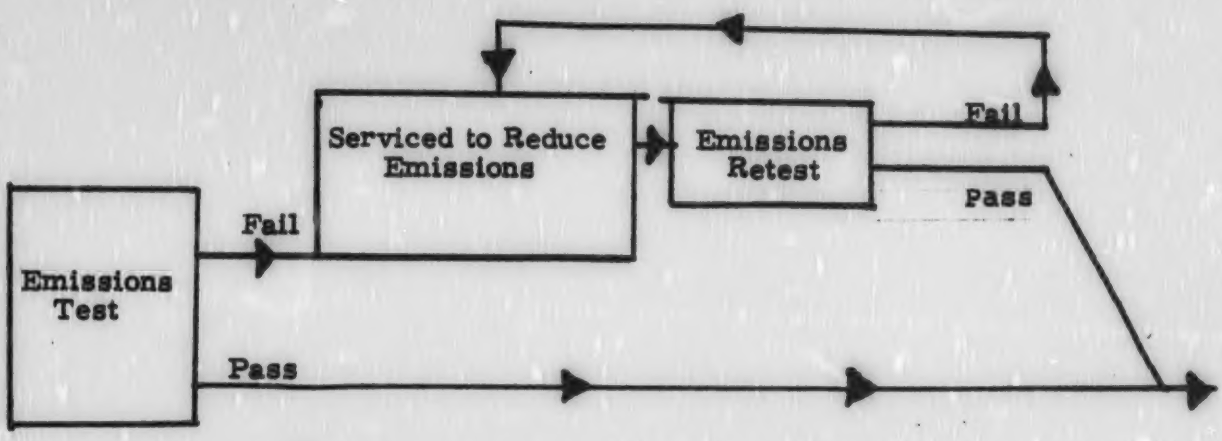
- Type of Inspection Used:
  - Idle
  - Loaded
- Failure Criteria for Inspections
- Frequency of Inspections
- Program Idiosyncrasies:
  - New car waivers
  - Waivers for high expense repairs
  - Reinspection policies
  - HDV waivers

EXTERNAL FACTORS - external to any individual program's specifications

- Quality of Inspection Mandated Maintenance
- Tampering
- Extra Voluntary Maintenance Peformed by the Public
- Deterioration Rates:
  - Under normal usage and maintennce given no I/M program
  - During the period between I/M inspections
  - From one I/M cycle to the next I/M cycle
- Manufacturers Design and Production Practices
- Relationship of short test results to FTP test results

Figure 1

FLOW OF A SINGLE INSPECTION /MAINTENANCE CYCLE

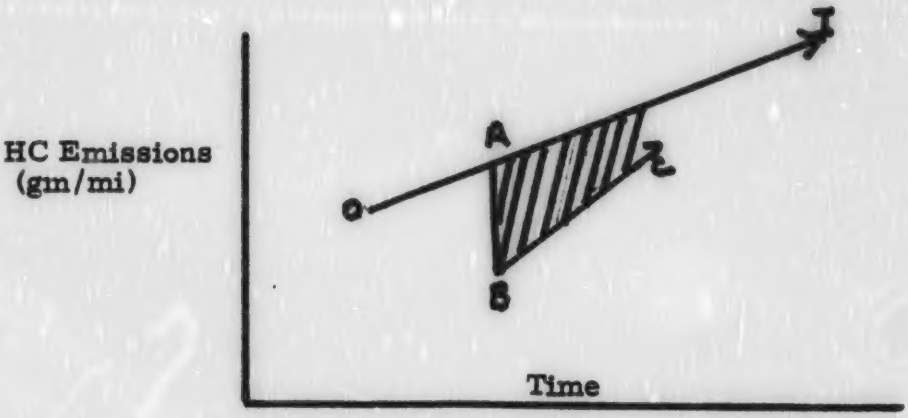

Emissions Test
Fail
Pass
Serviced to Reduce Emissions
Emissions Retest
Fail
Pass

The emission reductions that can be derived as a result of the single I/M cycle outlined above are dependent on:

- the initial emissions reduction achieved by servicing the failed vehicle (Line $\overline{AB}$ in Figure 2),
- the rate at which vehicle emissions deteriorate - from serviced and unserviced vehicles after the I/M cycle is completed (Line $\overline{BC}$ in Figure 2), and
- the rate at which emissions would deteriorate in the absence of I/M (Line $\overline{OAI}$ in Figure 2).

Figure 2

MODEL OF A SINGLE INSPECTION/MAINTENANCE CYCLE



Line $\overline{AB}$ = initial change in emissions (averaged over all vehicles)
Line $\overline{BC}$ - emissions over time within a single I/M cycle
Line $\overline{OAI}$ = emissions over time in the absence of an I/M program
▨ = emissions reductions achieved

NOTE: The line $\overline{BC}$, representing emissions over time after a single I/M cycle, has been intentionally cut off after a specified time because an operating I/M program actually consists of repeated I/M cycles.

The extent to which overall emissions are reduced initially depends on the selection of cars to be serviced and the quality of service performed. The first factor depends on flunk rates and certain program idiosyncracies such as testing exemptions for very new or very old vehicles, reinspection policies and waiver provisions. Service quality is affected by mechanics' emissions repairs skills, the emissions diagnostic equipment/information available to him/her and the extent to which (s)he is able to make use of this information.

The rate at which emissions deteriorate after the initial, maintenance-induced emissions reduction,[a] while partly a function of the initial service that failed vehicles receive is primarily determined by the characteristics of the engine and emission control systems, by the level and extent of "normal" (voluntary) maintenance [b] to which the cars are subjected, and by any intentional (or unintentional) tampering. Because of its dependence on the basic characteristics of the engine and emission control systems, the rate at which emissions deteriorate between I/M cycles is almost entirely beyond the control of any individual I/M program.[c]

The rate at which average emissions would deteriorate in the absence of the I/M cycle impacts I/M effectiveness estimates as it is the base from which the emission reductions obtained are measured. Like emission deterioration rates this factor is also beyond the control of any individual I/M program. It is influenced by the same factors that effect emissions deterioration between one I/M cycle and the next, i.e., engine emission control system characteristics, "normal" maintenance, and tampering.

C. Repeated I/M Cycles

In an operating I/M program vehicles are subjected to inspections on a periodic basis. Thus, emissions over time from a group of vehicles subject to an I/M program can be pictured as having the "saw-tooth" shape indicated in Figure 3.

---

[a] It is explicity assumed that emissions will deteriorate (increase in quantity) over time. This is discussed further in the next section.

[b] "Normal" maintenance is maintenance that is regularly performed by vehicle owners to keep their car running properly. It is the level of maintenance that occurs independent of I/M.

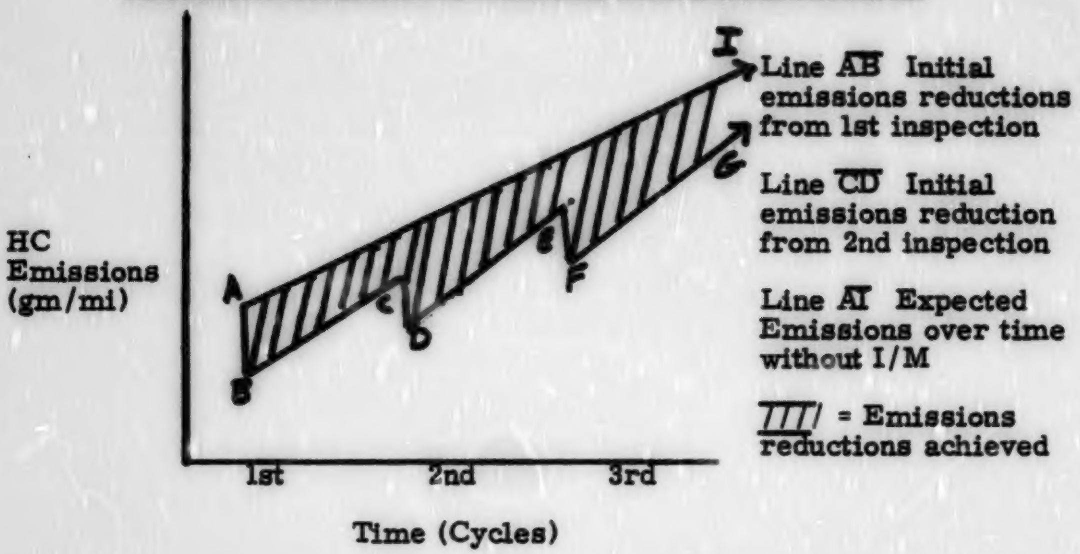
[c] While the rate of "normal" maintenance may be positively influenced by the mere existence of an I/M program (e.g., vehicle owners will attempt to keep their cars in a better state of maintenance to avoid flunking the inspection), to date there is no evidence of this effect in States where I/M programs exist. Tampering can, of course, be influenced by a separate, complementary anti-tampering program. It is also possible that the knowledge that the I/M cycle will be repeated may also have a self-enforcing effect and limit tampering.

The emission reductions that are possible as a result of repeated I/M cycles are dependent on:

- the initial emissions reductions caused by successive I/M cycles (lines $\overline{AB}$, $\overline{CD}$, and $\overline{EF}$ in Figure 3),
- the rates of deterioration between inspections (lines $\overline{BC}$, $\overline{DE}$ and $\overline{FG}$ in Figure 3), and
- the "effective deterioration rate" that is, the maximum average emissions reduction achieved over time resulting from the repeated I/M cycles. (This is a function of the first two factors.)

Figure 3

MODEL OF EMISSIONS OVER SEVERAL I/M CYCLES



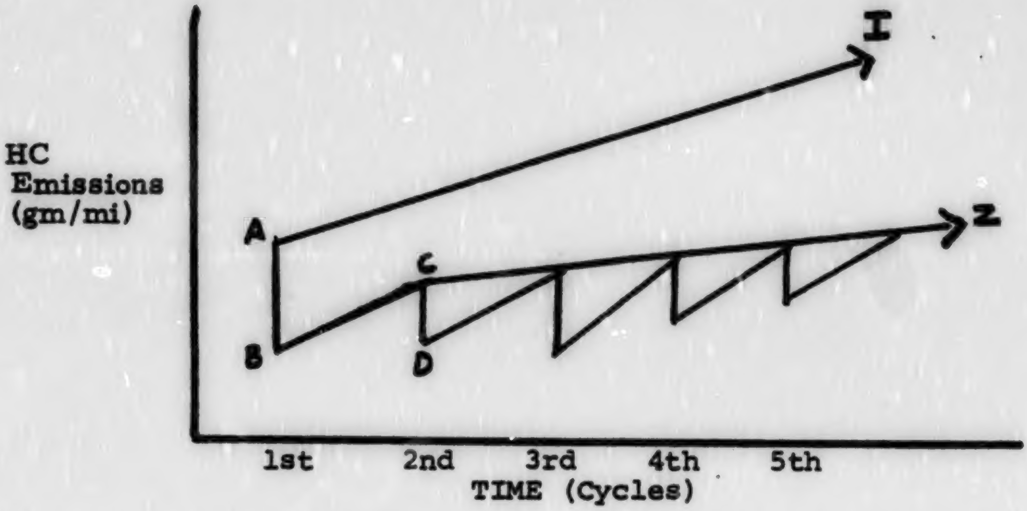
It is possible that the effective deterioration rate of vehicles subjected to repeated I/M cycles could be significantly lower than the deterioration rate would have been in the absence of an I/M program. Such a situation is illustrated in Figure 4. Achievement of a decrease in the long-term deterioration rate could be achieved if the percentage reduction in emissions was the same for each cycle and emissions one year after inspection and maintenance were lower than what they would have been without I/M, i.e., point C in Figure 4 must be below line $\overline{AI}$. a/ Should this be the case in the real world, the average effectiveness of an I/M program over the life of a vehicle would be significantly greater than the emissions reduction effectiveness obtainable over the first I/M cycle. In fact, the effect of repeated I/M cycles on long-term deterioration rates seems to be the key external variable capable of exerting considerable upward influence on I/M effectiveness estimates. However, there is at present inadequate data to substantiate the existence or extent of this effect.

---

a/ Alternatively the percentage decrease in emissions after each successive cycle could increase, even though by the end of each cycle emissions returned to line $\overline{AI}$.

Figure 4

MODEL OF THE POTENTIAL OF REPEATED I/M CYCLES TO REDUCE DETERIORATION RATES



Line $\overline{AI}$ = emissions over time in the absence of I/M
Line $\overline{CZ}$ = "Effective Deterioration Rate", e.g., maximum average emissions over time as a result of repeated I/M cycles

III. CRITICAL FACTORS

A. Emissions in the Absence of I/M

EPA estimates that HC emissions from controlled precatalyst vehicles generally deteriorate at an average of 0.5 grams/mile each year. For 1969 thru 1974 vehicles this is equivalent to a deterioration rate of about 15% per year (actually 12% to 17% per year).[a] The uncertainty in this assumption, due to the wide variation in all available data sets, is approximately ±1.0 gm/mi/yr or 200% [b].

Although the uncertainty in the estimate of emission deterioration in the absence of I/M is large, the impact of this uncertainty on I/M effectiveness estimates is relatively small. This is because the percentage effectiveness of an I/M program is essentially the emissions reduction obtained, in gm/mi, divided by the total emissions, in gm/mi in the absence of an I/M program. Since total average emissions in the absence of I/M are large relative to any I/M-induced emissions reductions (roughly 10 to 1 for pre catalyst vehicles), small changes in the total average emissions base figure due to changes in the deterioration rate (which is also small relative to total emissions) alter I/M effectiveness estimates only slightly. Given a .5 gm/mi/yr deterioration rate and a .6 gm/mi I/M-induced emissions reduction, the uncertainty of 200% in the deterioration rate is equivalent to an uncertainty of approximately 10% in the estimate of overall I/M effectiveness.[c] However, the rate of emissions deterioration over time in the absence of an I/M program can alter estimates of I/M's effectiveness in three ways:

---

[a] Ref. 20

[b] That is, we can say that the rate of emission deterioration from controlled precatalyst vehicles is between 1.5 and -.5 gm/mi/yr and have a 95% chance of being correct. HC emissions deterioration rates in terms of vehicle mileage seem to display much smaller variations.

[c] Consider an example:
1. average initial emissions reductions from I/M = .6 gm/mi
   initial emissions from 72 MY vehicles = 5.00 gm/mi
   deterioration = .5 gm/mi/yr
   emissions after 1 yr. from 72 MY = 5.50 gm/mi (No I/M)
   average emissions from 72 MY = 5.25
   I/M EFFECTIVENESS = 5.8%
2. change deterioration rate ±1.0 gm/mi/yr

deterioration rate = 1.5 gm/mi/yr	deterioration = -.5 gm/mi/yr
emissions after 1 yr. = 6.50 gm/mi	emissions after 1 yr. = 4.50 gm/yr
average emissions = 5.75 gm/mi	average emissions = 4.75 gm/mi
I/M EFFECTIVENESS 5.2%	I/M EFFECTIVENESS = 6.3%

of vehicle mileage display much smaller variations.

1. if the deterioration rates over several years in several I/M cycles with and without I/M are different, then, as discussed earlier, the effectiveness of an I/M program could be increased or decreased.

2. if vehicles experience excessively high deterioration rates, the potential of I/M-induced maintenance to reduce average emissions levels may be increased (this appears to be the case for the catalyst-equipped vehicles now in use).

3. if, even though average emission rates were not effected, emissions at the end of a cycle had not returned to the levels that would have been expected in the absence of an I/M program.

B. Single Cycle I/M Effectiveness

o Initial I/M Induced Emissions Reductions

The average HC emissions level from all vehicles in a fleet of controlled, precatalyst vehicles can be reduced immediately after the initial maintenance by 10 to 25 or more percent. These emission reductions have been well documented and analyzed.[a] Table 4, drawn from a recent California Air Resources Board study illustrates the types of emission reductions now being observed in the field. Analyses have focussed on the percentage of emission reduction that could be achieved as a function of certain critical variables.[b] Three variables thought to be particularly important are:

- failure criteria or rate,
- test mode, and
- quality of inspection mandated maintenance.

As will be seen in the following discussion, the uncertainty in initial emission reductions achievable as a function of a given set of these and other internal variables is relatively small compared to uncertainties generated by other external variables discussed later in this paper.

Failure Rates

Table 5 presents EPA's previous best estimate for emission reductions as a function of failure rate on an idle test. In general there is very little disagreement on these numbers.[c] A comparison of the values presented in Table 5 with the results of more recent empirical studies (summarized in Table 4) demonstrate very close agreement. The two empirical values are only five and twenty percent off on the low side from the values predicted in Table 5. Considering the totally different composition of the vehicle fleets in the more recent studies, this agreement is remarkable.

---

[a] See Ref. 11, 12, 16, and 23.

[b] In some analyses (e.g., OMSAPC's model) additional factors have been included such as an allowance for catastrophic failure.

[c] They of course represent averages. Older vehicles tend to improve more with maintenance.

TABLE 4

INITIAL EFFECT OF MAINTENANCE ON HC EMISSIONS FROM IN-USE VEHICLES

Study	Model Year	Initial Emissions mean (gm/mi)	After Maintenance mean (gm/mi)	Emissions (%)	Comments
California a/ Air Resources Board (1976)	'68 - '74 California vehicle population	4.50	3.54	-21.3%	Simulated I/M; 49% actual failure
		3.90	3.49	-10.5%	All vehicles tuned to manufacturer's specifications
		4.50	3.58	-24.4%	All vehicles subject to mandatory maintenance and parameter inspection
California b/ Air Resources Board	631 '55 - '74 California vehicles	4.79	3.97	17%	Idle test; 35% failure rate
		5.14	4.17	19%	Loaded test; 35% failure rate

a/ Based on Ref. 10.

b/ Based on Ref. 2.

TABLE 5

INITIAL HC EMISSION REDUCTIONS BY FAILURE RATES FOR CONTROLLED PRECATALYST VEHICLES a/

Idle Test Rejection Rate (%)	Initial % HC Reductions
10	12
20	16
30	20
40	22
50	22

---

a/ Based on twice the annual credits given in 40 CFR 51, Appendix N.

The conclusion drawn from these numbers is that effectiveness increases significantly with increasing failure rates up to about 20 to 40%.[a] Beyond this range of failure rates the benefit in emissions reductions increases more slowly than the failure rate. In fact, several studies have indicated that, at failure rates in excess of about 80%, emisison reductions actually decrease. The explanation offered is that with 100% maintenance the level of emissions from some of the originally low level emitters is increased as a result of the required maintenance.

All of the studies on which our analysis is based were, like operating programs, conducted with total failure rates applying to both CO and HC failures and no effort has been made to analyze the effects of varying the ratio of vehicles failing for one pollutant or the other. In fact, actual experience in Oregon and elsewhere clearly indicates that most inspection failures are for CO alone. Typically,twice as many vehicles fail I/M inspections for CO as for HC. This ratio may be reasonable given the selection of emission failure points and the fact that CO deterioration rates from actual in-use vehicles are significantly worse than is projected by current emission factor estimates while HC deterioration rates have been more reasonably estimated by current emission factors. However, most studies indicate that maintenance to pass a reinspection after a CO failure will also result in decreased HC emissions. This factor will tend to mitigate any negative effect of lower HC failure rates on the HC emissions reduction effectiveness of I/M programs.

Type of Inspection

The major types of inspections are:

1. mandatory maintenance,
2. parameter inspection, and
3. emissions inspection.

Mandatory maintenance requires all vehicles to perform regular, manufacturer-specified maintenance on all parts. Parameter inspection requires all vehicles to have the parts and systems affecting emissions inspected and, if necessary, adjusted. Emissions inspection requires all vehicles to have their tail pipe exhaust measured and, if the emissions exceed pre-set standards, to be repaired. Emissions inspections may use an idle (samples exhaust at idle speeds only) or a loaded (samples exhaust at several different driving speeds as well as idle) mode test. All of these inspections are designed as alternatives to the very expensive and time consuming full FTP.

---

[a] See References 11, 15, and 35. In Reference 10 (pp. 1-11) it is concluded that no benefit is gained from failure rates greater than 30%. A similar conclusion is reached in Reference 11, p. 72.

A number of studies have attempted to quantify the variation in initial emissions reductions as a function of type of inspection. a/ An EPA comparison of several alternatives showed emissions inspections were more effective than parameter inspections or mandatory maintenance. However, the difference was not statistically significant at the 90 percent confidence level. b/ Figure 5 and Table 6 present the results of another study. Differences caused by type of inspection seem to be overwhelmed by the random variations in the data.

We believe that for precatalyst vehicles, the variability of emission reductions by type of inspection is mainly a function of service quality, which differs depending on the diagnostic information provided to the service industry c/.

---

a/ See Ref. 3, 10, 12, 16 and 35.

b/ See page 242 of Ref. 26.

c/ This should be true as long as the test employed is reasonably capable of picking out high emitters. While available data on the ability of short tests to pick out high emitters is somewhat mixed, it is generally agreed that very high emitters can be identified. The partially unresolved question for I/M is: what is the FTP emission rate associated with given short test cut points? This has not been a problem for operating I/M programs because failure cut points turn out to be very high relative to applicable standards. However, EPA's failure to promulgate a correlatable short test under § 207(b)(1) has been a cause for the delay in developing a § 207(b) warranty program.

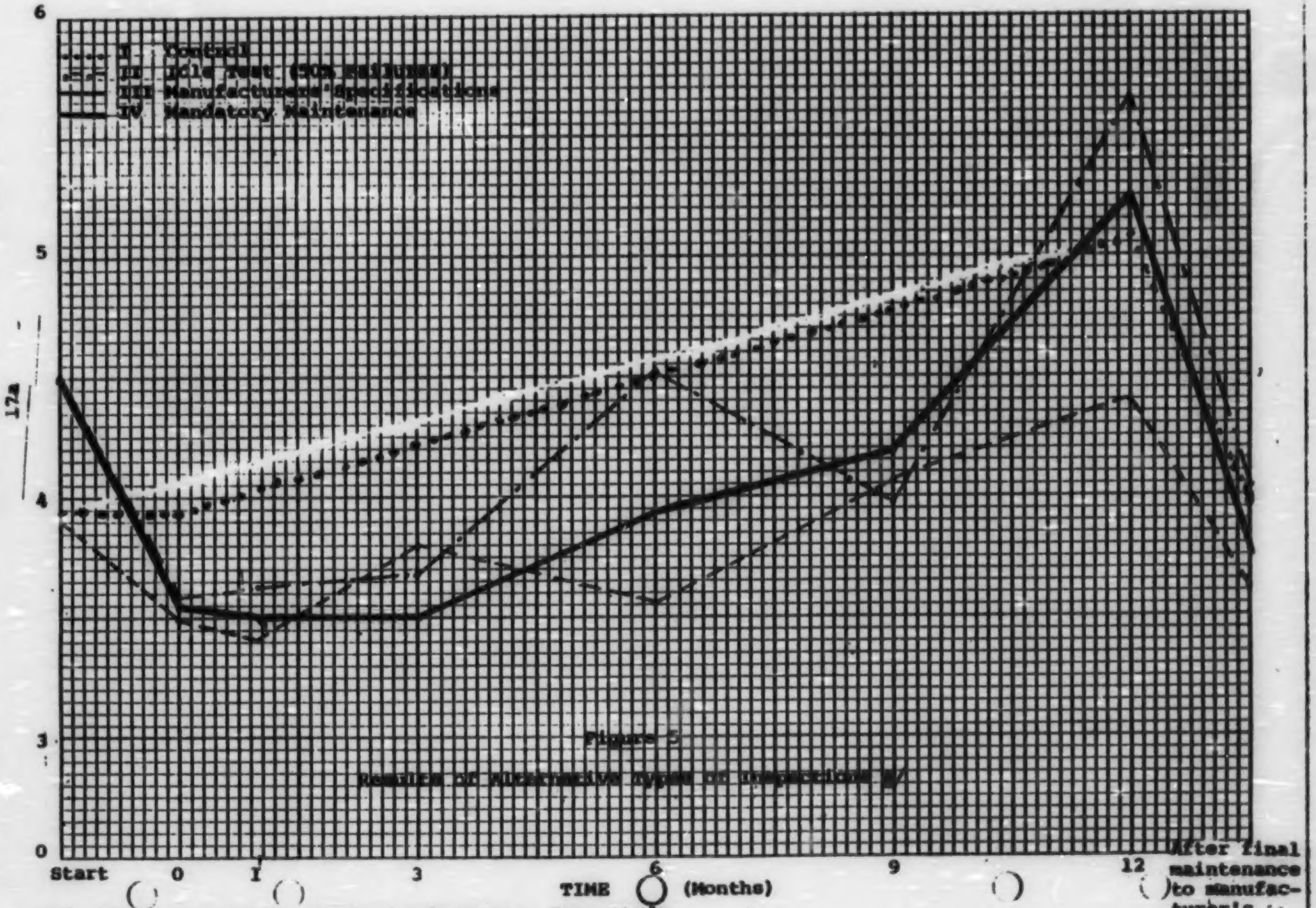


Figure 5

Results of Alternative Types of Inspections a/

a/ Based on results of Olson Laboratory, Inc. study.

TABLE 6

HC DETERIORATION RELATIVE TO BASELINE EMISSIONS a/

Vehicle Group	Immediately After Initial Maintenance	One Year After Initial Maintenance	Immediately After Second Round of Maintenance b/
1 - Control	-	+29%	+1%
2 - I/M	-21%	+16%	- 14.5%
3 - Manuf. Spec.	-11%	+13%	-7%
4 - Parameter	-20%	+25%	-11%

---

a/ Based on Ref. 12 data as portrayed in Figure 4.

b/ The second round of maintenance consisted of tuning all cars in all groups to manufacturers specs.

Loaded tests provide considerably more diagnostic information than idle tests. Consequently, EPA has assumed that a loaded test could produce slightly better emissions reductions than an idle test if the available diagnostic information was well utilized (Appendix N). A recent California study (Ref. 2) has cast some doubt on this assumption. The California study indicates that, given the present capability of the service industry, loaded and idle tests produce emissions reductions that are not significantly different. This research is all the more surprising because all the mechanics involved in this study received training in emission-related repairs and in the use of the diagnostic information provided by each test. a/

From an effectiveness viewpoint the selection of an inspection test should be based heavily on its expected impact on the service industry. Since full utilization of the information provided by the loaded test seems difficult to achieve, in the immediate future the idle test, less expensive and equally effective, is at present a more cost-effective testing regime. b / However, full resolution of this issue for any proposed I/M program would have to include an assessment of existing mechanic emissions repair skills and planned training programs as well as the costs of alternative test modes.

Quality of Inspection-Mandated Maintenance

As indicated above, this appears to be the most sensitive unknown as far as initial emission reductions are concerned. Results from an early Office of Mobile Source Air Pollution Control model indicate that, at a reasonable 30% failure rate, I/M effectiveness for HC can vary from 15% to greater than 28% when service is improved sufficiently so that repaired vehicles meet a set of deteriorated emisisons standards c/ as opposed to being repaired just enough to pass the inspection test. d/ There is, however, no reason to assume that this full potential could ever be realized in actuality for all vehicles even with optimum maintenance. Emissions from some vehicles may just not be adequately lowerable at any reasonable cost. e/ The State of New Jersey has found that the percentage of vehicles failing the I/M test after maintenance has decreased with time. From this it is impossible to conclude that I/M programs can generate an improvement in the quality of emissions-related maintenance performed.

---

a/ The quality of this training was not assessed as part of this effort.

b/ NOTE: In areas where ambient NOx concentrations are high, the loaded mode test may prove more cost-effective overall since it has the capability to control NOx as well as HC and CO. The idle test simply does not have this capability.

c/ Equal to the mean of the passed vehicles.

d/ See Ref. 35.

e/ Certain studies have found that even after intensive maintenance by carefully trained mechanics, some vehicles continue to fail short test standards.

37.

The allowable credit implied by current EPA regulations (based on '73 Olsen Study) adds 4 - 8 percentage points to I/M's initial emissions reductions if the I/M program uses a test mode providing diagnostic information. This is probably the most reasonable estimate of the impact that significantly improved maintenance quality can have on initial emissions reductions. However, the recent data from California indicate that even intensive mechanic training may not immediately produce the desired gains in I/M effectiveness.

In addition, New Jersey found that the probability of a vehicle failing the reinspection test after it has received maintenance is greater for those vehicles that originally failed because of excess HC emissions than for those that originally failed because of excess CO emissions. This would seem to indicate that it is harder to service cars to minimize HC emissions than it is to service them to minimize CO emissions. One implication of this is that EPA-supported mechanic training programs may have to emphasize repairs to reduce HC emissions.

Emissions Deterioration After Maintenance

o Emissions Deterioration in the Absence of Excessive Tampering o

The shape and magnitude of after-maintenance deterioration (in the absence of excessive tampering) can have a major impact on overall I/M effectiveness estimates. Assume, for now, that at the end of a year emissions are the same as they would have been had there been no inspection. This end of year emissions level can be reached via three different deterioration rates. (see Figure 6):

- a very rapid initial deterioration, e.g., almost returning to the initial emissions level within, say, the first 3 months, then leveling off , and
- a linear rate of deteriroation throughout the year, or
- a very slow initial deterioration, say, for nine months, and then very rapid deterioration.

Traditionally, EPA has assumed a linear deterioration rate. This assumption leads to an estimate for annual I/M effectiveness equal to about one-half the initial emissions reduction noted above this hypothesis, (e.g., Ref. 4. (10 24% initial reduction, 5 12% annual reduction). This was the assumption used in the existing EPA guidelines.

While, as indicated above, the extent of initial emissions reduction is fairly well known, the subsequent deterioration has been empirically studied for a full year only once (Ref. 12). The resulting data are portrayed in Figure 5 and are summarized in Tables 6 and 7. The conclusion that may tentatively be drawn from this effort is that deterioration after maintenance has a concave shape, i.e., initial deterioration is slow and then increases. b/ (See Table 7.) Assuming a concave deterioration

---

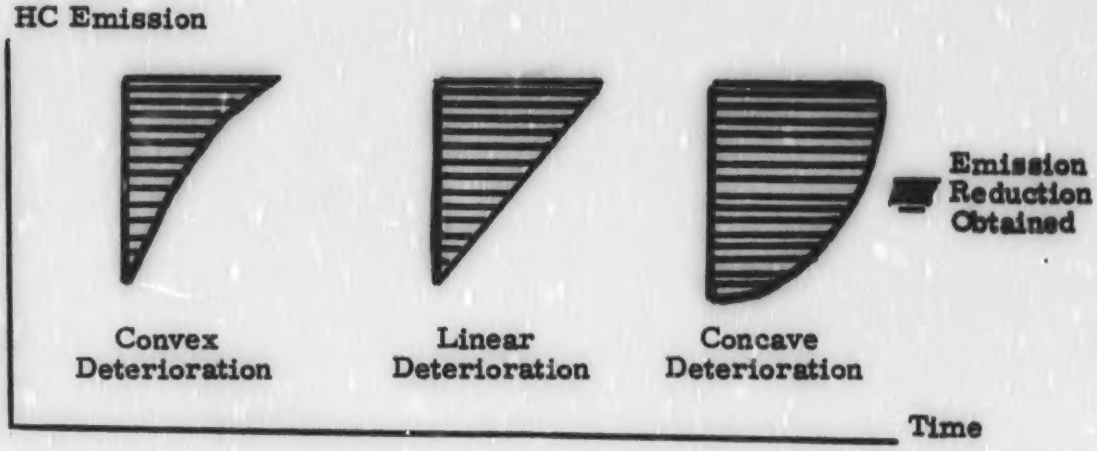
a/ This, of course, is unlikely to be the case.

b/ Other more limited and specialized studies exist that do not fully support this hypothesis, e.g., Ref. 4.

rate, the SIP emission reduction credits given in Appendix N are conservative. Based on an analysis of the qualitative results, a best judgement estimate as to the effectiveness of a single I/M cycle is 1.4 times the credits given in Appendix N. This best estimate is probably also close to the upper limit that might reasonably be expected.

Figure 6

IMPACT OF POST MAINTENANCE DETERIORATION ON I/M EFFECTIVENESS OVER A SINGLE I/M CYCLE



Observation: o An extremely convex deterioration curve would result in I/M yielding almost no emission reduction benefits. This type of curve could be is effectively "produced" by significant post-inspection/reinspection tampering.

o An extremely concave deterioration curve could yield up to twice as great an emission reduction benefit as a linear deterioration curve.

Best Estimate: o Emission reductions are probably 1.4 times greater than the conservative linear deterioration assumption would imply. a/

---

a/ The impact on effectiveness over one cycle of the different deterioration rates depends to a limited extent, on the end of year emission levels. The impact of end of year emission levels on effectiveness is discussed in detail in the section on repeated cycles.

TABLE 7

DETERIORATION OF AVERAGE EMISSIONS FROM A FLEET AFTER TESTING IN A SIMULATED I/M PROGRAM a/

Study	Date	% of Initial Effectiveness Lost Over Time d/	I/M Program	Fleet	Comments
CARB b/	6/73	22%/6 mo.	Manufacture specs. by private mechanics	1957-70 Calif. pop.	Emissions after 6 mos. were still 29% lower than preinspection emissions.
CARB c/	1976	83%/9 mos. 175%/yr. e/	50% target Failure Rate, Idle Test - 41% Actually Fail	1968-74 Calif. pop.	In all cases, gross emissions were less than for the no I/M control group.

---

a/ Unscheduled maintenance is a key variable not fully reflected in the data presented in this table.

b/ Based on Ref. 11.

c/ Based on Ref. 12.

d/ See Table 4 for initial effectiveness levels.

e/ At the end of a year 175% of the initial effectiveness had been lost. Thus, at nine months only one-half the annual loss had occured.

If the after maintenance deterioration curve also is concave then one must conclude that semi-annual inspection cycles would produce only marginal improvement in effectiveness over an annual inspection cycle. This is because the benefits of the initial maintenance have not been significantly reduced after only six months (see Table 7). Therefore, the benefit of additional maintenance at six months is probably marginal.

Tampering

Excessive tampering after a vehicle has completed an I/M inspection/reinspection could result in a significant reduction in the effectiveness of an I/M program since such tampering effectively creates a convex deterioration curve. Based on data from a New Jersey tampering survey a/, we estimate that the effectiveness of I/M program for precatalyst vehicles will be reduced by 1% for every 1% of the vehicles tampered with after passing their inspection. b/ No estimate can be made of the effect of this factor since no data exist on the incidence of after inspection/reinspection tampering.

An argument can be offered that the mere existence of an I/M program will actually reduce tampering from what it would have been without I/M because of the liability of being caught at inspection time. For precatalyst vehicles where driveability problems are not created by tuning for emissions this argument is probably sound. Furthermore, the Mobile Source Enforcement Division has reported that a second survey one year later in New Jersey identified less tampering. Thus, unless vehicles are "retampered" prior to the inspection time, it appears that either the I/M program is acting as a deterrent to tampering or else mechanics are learning how to work with emissions control. c/

---

a/ See of Ref. 8, p. 6. This estimate is based on idle mode emissions test data.

b/ Based on the assumptions that the percentage change in emissions as measured on the FTP would be proportional to the percentage change as measured on the idle test.

c/ The New Jersey data were gathered at State inspection stations from vehicles immediately after (re)inspection, rather than, say, several weeks later when post-inspection tampering might be more reasonably expected to occur.

C. Repeated Cycle Effectiveness

In the past, EPA has assumed that the percentage of emissions reduction obtained from successive I/M cycles was identical to that achieved in the first cycle. The assumption of a repeat performance was reasonable given a further assumption that one year after an I/M cycle emissions return to the levels that would have existed in the absence of I/M. However, on solely speculative grounds it was possible to argue that an effective I/M program might slow or even stop the deterioration of emissions (see the Optimistic Scenarios in Figure 7) with vehicle mileage or age. The potential effect of such an occurrence can be seen by considering the extreme case where deterioration is stopped completely. In such a case, the absolute emissions reductions benefit from I/M would increase by the amount by which emissions would have deteriorated each year without I/M, e.g., 12 - 17%.[a]

A theoretical upper limit for the impact of this effect on I/M effectiveness estimates for precatalyst vehicles can be computed. Assume there is an upper bound on average HC emissions from 1972 vehicles of 9.0 gm/mi, the emission level if uncontrolled vehicles without I/M. If '72 vehicles start out emiting 3.0 grams/mile and increase at .5 gm/mi per year, the avereage lifetime [b] emissions rate would be 6.0 gm/mi. If the emissions rate were held to 3.0 grams/mile, that is, if the vehicles experienced absolutely no emissions deterioration whatsoever, then lifetime emissions would be reduced, on average, 50%, i.e., from 6.0 gm/mi to 3.0 gm/mi.

In fact, it is unlikely that the upper limit for controlled vehicles is as high as the upper limit for uncontrolled vehicles. If the upper limit were 7.0 gm/mi and the emissions rate were held to the design standard, then the maximum average long-term effectiveness would be only 40%.

A reasonable basis for the speculation that I/M would lower deterioration rates over the long term can be found in several sources of emissions data.

- Certification cars, which are very well maintained, deteriorated at a much lower rate than the vehicles in actual use. (Certification cars are, of course, hand tooled.)
- Many properly maintained in-use vehicles can, when tuned up, meet design standards (based on IUCP data); that is, point B in our model is at the design standard. It is reasoned that beginning an I/M cycle at this standard improves the probability that, at the end of the cycle, emissions will be below what they would have been without I/M, i.e., point C may be more likely to be below line $\overline{AI}$.

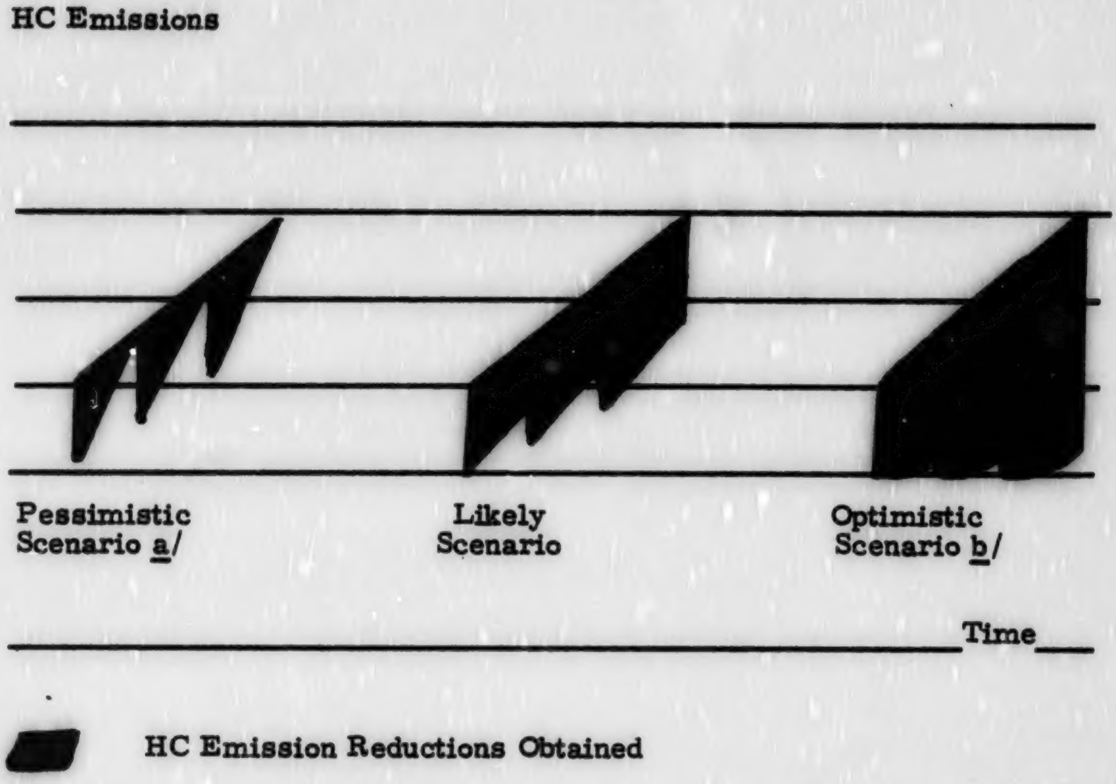
---

[a] Ref. 20.

[b] Assuming a lifetime of 12 years.

Figure 7

I/M PROGRAM EFFECTIVENESS FOR SEVERAL ALTERNATIVE SCENARIOS



---

a/ gains from I/M are the same for each repeated cycle
b/ deterioration halted completely

To date, the only study that provides any empirical insight into this issue is the Olsen study discussed above and summarized in Figure 5 and Tables 6 and 7. a/ Unfortunately, these data shed no definitive light on this issue.

In support of the contention that I/M lowers deterioration rates over time, the study found that the vehicles participating in a testing and maintenance regime were generally in somewhat better emissions condition than the control group.

- After one year emissions from the inspected and maintained vehicles were lower than emissions from the control group (e.g., a 13 to 25% increase over baseline emissions versus a 29% increase). For the test regime vehicles point C in Figure 4 was below Line AI.
- After the second round of maintenance, b/ emissions in tested and maintained vehicles were only slightly higher than emissions after the first round of maintenance while maintenance performed on control vehicles after 1 year was unable to lower emissions, below the original baseline. In terms of the model, for tested vehicles, point D is slightly above point B while for control vehicles, point D is no lower than point A.

In addition, since vehicle fleets involved in this experiment represented vehicles several years old, it is possible that if only new vehicles were used, the results would have indicated larger differences between the controlled and tested groups. Furthermore, the results of the IUCP program have been cited by some as evidence that deterioration rates could be lowered.

However, these same results can be viewed as supporting the present EPA assumption that emissions at the end of the I/M cycle have deteriorated back to where they would have been without I/M.

- Although emissions from test vehicles one year after maintenance were lower than emissions from control vehicles, the emissions deterioration rate of tested vehicles (13 - 25%) is not significantly different from the emissions deterioration rate without I/M found by other EPA studies (12 - 17%). Thus, the magnitude of deterioration found in the Olsen study is consistent with EPA's current assumption of returning to "no-I/M" emission levels, suggesting that there is no increasing benefit from repeated cycles.

---

a/ Both MSAPC and OTLUP have developed models assuming decreasing deterioration under I/M. The implications of these models has been carefully reviewed to obtain insight into the effect of this assumption on I/M program effectiveness. Any changes in allowable SIP emission credits will be based largely on these computer simulation models.

b/ All vehicles received maintenance in the second round.

- After the second round of maintenance with all vehicles tuned to manufacturers specifications, emissions from test regime vehicles exceeded emissions after the first round of maintenance. Thus, even with the most optimal level of maintenance, unlikely to occur in the real world, point D in Figure 4 is still at least 5 - 10% higher than point B. [a]

It is concluded here that to date there is not sufficient empirical evidence to either support or refute claims that I/M can slow down deterioration rates. We do, however, believe that the current EPA assumption, that subsequent cycles produce the same effect as the first, represents a lower bound on effectiveness since it is clearly unreasonable to expect long-term average emissions deterioration rates to get worse with an I/M program. Such a result would require that an I/M program have just the opposite impact on owner maintenance than it is designed to have.

Based on a review of the model used here and other available data, some additional observations on long-term deterioration rates can be made:

1. If the long-term deterioration rate were slowed down, the benefit for a given model year would increase each year throughout the useful life of each individual vehicle. However, for the program as a whole the benefit would be equivalent to only the benefit achieved by the fourth cycle. [b]
2. The older a vehicle is the less potential benefit there is from I/M's impact on long-term deterioration, i.e., deterioration that has already occurred can not be fully eliminated.
3. Full benefit from this affect would require constant cut points. Constant cut points would increase failure rates over time unless voluntary maintenance was increased. Thus, increasing failure rates would be expected. [c] This would probably be politically unacceptable. Therefore, unless there were a significant increase in the rate of voluntary maintenance, I/M cut

---

[a] EPA's Mobile Source Enforcemnt Division reached a different conclusion based on a detailed review of the underlying data. They rejected data from: 1) vehicles not completing the study and 2) from one vehicle with very high emissions. Based on their revised data they concluded that point C in Figure 4 was below line AI, i.e., the deterioration rate appeared to have been lowered.

[b] This is because, for a stabilized program, the average vehicle age would be only four years.

[c] Even subject to repeated I/M cycles vehicles are expected to deteriorate with time. As a class of vehicles deteriorates, a greater and greater percentage of them could be expected to exceed a fixed standard.

points might have to be loosened over time to avoid excessive failure rates. Such a loosening of cut points would reduce any actual slowing of deterioration rates.

4. Available empirical evidence tends to indicate that the same vehicles would fail year after year.
5. The extent of the effect of lowered deterioration rates depends on the magnitude of the difference between long-term deterioration rates with and without I/M. Therefore, the higher the non-I/M deterioration rate the greater the potential benefit could be.

IV THE SPECIAL CASE OF CATALYST-EQUIPPED VEHICLES

Data on catalyst equipped cars is even more scarce than data on precatalyst vehicles. At present, there is only one set of data on the effectiveness of an I/M program in reducing HC emisisons. a/ Based on a study of 33 vehicles, the California Air Resource Board's May, 1976 Riverside study found that the initial maintenance induced emissions reductions for catalyst equipped vehicles was greater than for pre-catalyst vehicles. No information is available from in-use catalyst vehicles on how they deteriorate after maintenance or on the effect of repeated I/M cycles.

While the CARB study might indicate greater percentage benefits for I/M on catalyst equipped vehicles, countering arguments exist. Data from EPA's 1974 Emissions Factor Program indicate that the unexpectedly high emission levels from catalyst vehicles is probably due to tampering or more specifically emissions maintenance aimed at improving driveability. The larger initial emissions reductions experienced by these early catalyst vehicles may be due to the forcing of proper service on these maladjusted vehicles, that is, checking the tampering resulting from driveability problems. Some of these driveability problems may be eliminated by manufacturers in later model year vehicles. This could eliminate the increased initial emission reductions found in the CARB study. Another approach to this tampering problem presently being explored by OAWM is to require (or encourage) manufacturers to design cars that cannot be tampered with, e.g., eliminate the present ability to adjust idle speeds on in-use vehicles. This approach would continue the general policy of putting the pressure for reducing vehicle emissions on the manufacturers whenever possible. If this approach is effective, it would result in decreasing the potentially greater benefits in percentage terms of I/M now possible for catalyst-equipped vehicles.

Although only tentative conclusions can be reached about I/M's effectiveness in reducing HC emissions from catalyst vehicles, our best guess is that an I/M program will produce about the same percentage emissions reduction for catalyst-equipped vehicles over time

---

a/ See Ref. 2.

as for precatalyst-vehicles. Although the initial percentage benefit from early catalyst cars may be greater, the absolute reductions in kilograms of HC emitted would only be, at most, half as great.

The relative reductions in total (stationary source plus mobile source) HC emissions will also be smaller. Hence, the relative cost-effectiveness of I/M, assuming costs remain relatively constant, will be less for catalyst-equipped vehicles than for precatalyst vehicles.

In addition to issues involved in computing effectiveness estimates, catalyst cars raise some unique program implementation issues which may in turn influence I/M effectiveness.

- Are short tests capable of accurately identifying high-emitting catalyst cars? Both EPA's '74 EFP and CARB's Riverside Study indicate that short tests have this capability.

- Will it be possible to determine if it is a catalyst or an engine malfunction that is producing the excessive emissions? a/ The catastrophic failure rate for catalysts in use remains unknown; if it is high then the benefits of I/M programs applied to catalyst equipped vehicles will be much higher than this paper is now estimating.

- Diagnosis of engine malfunctions may be more difficult. This may necessitate increased study by EPA and more effort into mechanic training. b/

- Will the cost of catalyst replacement, particularly when it must be borne by the consumer (as will always be the case after 50,000 miles), generate significant adverse public reaction? This adverse reaction is a major policy issue that must be faced.

Nonetheless, the overall impact of I/M programs will not be significantly influenced by I/M's effectiveness on catalyst equipped vehicles until the early 1980's, by which time the above identified issues should be resolvable. The current impact of catalyst equipped vehicles is small because emissions from precatalyst vehicles dominate total emissions. This will continue to be the case through about 1980, c/ unless the catalyst technology turns out to be totally ineffective in-use.

---

a/ See Ref. 10.

b/ See page 20 of Ref. 74

c/ However, the year through which precatalyst vehicles will dominate total emissions will vary by locality, depending on each area's mix of old and new vehicles.

47.

V. FACTORS OUTSIDE OF THE MODEL

A number of factors that significantly effect the overall effectiveness of an I/M program are not included in the previous discussion:

- Evaporative emissions are a significant fraction of HC emissions from motor vehicles. "According to EPA, the average daily evaporative HC emissions from new cars are now slightly greater than the average daily HC emissions from automobile tail pipes." It may become necessary to include a check on the level of these emissions in future I/M programs. No analyses to date have included this factor. Inclusion of this factor would allow I/M to serve a dual purpose. It is possible that the only feasible approach to an evaporative emissions check will be a check of specific hardware. At present there is no known test for evaporative emissions and according to OAWM it is unlikely that there will be one in the future.

- The relationship between I/M effectiveness in reducing HC emissions and the resulting ambient air quality impact will vary by geographic locality. It will depend on the general HC - Oxidant relationships as well as on:

  - the local inventory of vehicles (both by age, model type, mileage driven),
  - the percent of local HC from light duty vehicles,
  - the "local driving cycle" including typical ambient temperatures and percentages of cold starts.

  The only known effort to estimate the actual ambient air quality impact of an operating I/M program was undertaken by the State of New Jersey. a/ The effort identifies a positive empirical relationship between New Jersey's I/M program and ambient CO air quality levels. However, no such evidence was found with respect to ambient HC reductions. Analysis of the ambient impact of reducing vehicular HC emissions was, however, complicated by: the location of the HC monitors, low concentration levels, differences in emission and ambient standard measuring techniques, and the significance of non-vehicular emissions.

  Based on these uncertainties, no attempt has been made to review the HC reduction benefits of I/M that have been assumed in the existing SIPs.
  However, if one assumes that LDVs generate 5% of

---

a/ See Ref. 8.

the HC (and that Oxidants are a localized problem) then the air quality benefits assumed in the SIPs -- i.e., from about 2.0% to 5.0% -- are certainly within the bounds of what can be obtained . Of course revised emission factors published by EPA may necessitate increased HC reductions.

- It is reasonable to expect that an operating I/M program will have an impact on the quantity and timing of voluntary maintenance performed on vehicles, e.g., will people wait to service their cars until after the inspection or will they service them prior to the inspection and risk having to service them twice? No estimate can now be made as to the magnitude or even direction of this effect on HC emission reductions for those vehicles that would otherwise be reasonably well maintained.

- NOx emissions increase to a limited extent when maintenance is performed on a precatalyst vehicle to reduce HC or CO emissions. Thus, possible counter-productive affects of an I/M program on NOx emissions may have to be considered:
  - in those areas with ambient NOx problems, and
  - when control strategies are developed to meet the existing annual NOx ambient standard and the expected short-term NOx ambient standard.

  Of course, if I/M generated maintenance merely increases emissions up to their design levels, this factor may not be a problem in most areas; only five air quality control regions now have excessive ambient NO2 levels.

- The air quality impact of I/M will probably be greater with respect to localized high ambient CO levels than for ambient HC levels because motor vehicles represent a larger source by percentage of CO emissions than of HC emissions and because CO emissions appear to deteriorate faster than HC emissions.

- The selecton of a single short test by most I/M programs could result in manufacturer efforts to design cars to pass the chosen short test even when their deteriorated emissions would result in the vehicles failing the full FTP. This should not, however, represent a long term problem because idle/FTP emissions can be correlated on a yearly basis and if necessary, and for a price, the selected I/M test can be changed over time.

BIBLIOGRAPHY FOR PART A: EFFECTIVENESS

1. The Aerospace Corporation. A Review of Control Strategies For In-Use Vehicles, prepared for U. S. EPA, Dec., 1974.

2. Air Resources Board. Evaluation of Mandatory Vehicle Inspection and Maintenance Programs, State of California, May 1976.

3. Appendix N of 40 CFR 51, Federal Register, Vol. 38, No. 110, Friday, June 8, 1973.

4. Automotive Testing Laboratories, Inc. Retrofit Device Evaluation Program, Draft Contract Report prepared for U. S. Region VIII, Denver, Colorado, Jan., 1976.

5. Bernard, Jeffrey, et. al. Automotive Exhaust Emission Surveillance Analysis of the FY 73 Program, CALSPAN Corp. under contract with U. S. EPA, July, 1975.

6. Cutro, Joseph. Effects of I/M on Air Quality in Selected Areas, internal EPA summary based on CFR data, 1975.

7. __________. Nature of I/M Variables, and other internal EPA working papers.

8. Elston, J. and Cowperthwait, D. New Jersey's Auto Emission Inspection Program: An Assessment of One Year's Mandatory Operation, paper prepared for the 68th Annual Meeting - Air Pollution Control Association (#75-42.3), Boston, Massachusetts, June, 1975.

9. Forrester, James. Notes from personal interview, U. S. Department of Transportation, Washington, D. C., January 1976.

10. Grad, Frank P., et. al. The Automobile and the Regulation of its Impact on the Environment, Norman, Oklahoma, University of Oklahoma Press, 1975.

11. Gockel, J. L. An Evaluation of the Effectiveness of Automobile Engine Adjustments to Reduce Exhaust Emissions, prepared by Clean Air Research Company, for State of California Air Resources Board, June 22, 1973.

12. Gunderson, J. A., and Resnick L. Degradation Effects on Motor Vehicle Exhaust Emission, paper prepared for Automotive Engineering Congress and Exposition, Detroit, Michigan, 1976.

13. Kelly, Warren C. Exhaust Emission and Cost Evaluation of the State of California's Roadside Idle Emission Inspection Program, prepared by Scott Research Laboratory, Inc., for State of California Research Board, Dec. 7, 1973.

14. National Academy of Sciences. Motor Vehicle Emissions, Commission on Sociotechnicaal Systems, National Research Council. Washington, D. C., Nov. 1974.

15. Olson Laboratories, Inc. The Short Cycle Project, prepared under contract for the Office of Mobile Source Air Pollution Control, U. S. EPA, July 31, 1973.

16. Scott Research Laboratories, Inc. A Study of Maintenance for Reducing Vehicle Exhaust Emissions, prepared under contract for the Coordinating Research Council, Inc., July, 1973.

17. Shutler, Norm. Motor Vehicle Emission Control

18. Stork, Eric O. Carbon Monoxide Emission Estimates For Vehicles In Use, internal EPA memo to Bernard Steigerwald

19. __________. Emissions Deterioration Rates for In-Use Vehicles, internal EPA memo to Roger Strelow, Sept. 8, 1975.

20. __________. Highlights From Preliminary Analysis of Results from EPA Emission Factor Surveillance Conducted in Chicago, internal EPA memo to Roger Strelow, Nov. 14, 1975.

21. __________. Improvement of I/M Effectiveness Estimation, internal EPA memo to Roger Strelow, Oct. 7, 1975.

22. __________. Preliminary Data on Emission Performance of 1975 Model Year Cars, internal EPA memo to Roger Strelow, Feb. 25, 1976.

23. __________. Relationship of FTP Failures of 1975 Model Year Vehicles to Tune Up Adjustment Parameters, internal EPA memo to Roger Strelow, April 20, 1976.

24. Strelow, R. Facts on Inspection/Maintenance Operations, internal EPA memo to John Quarles, Nov. 6, 1975.

25. TRW. Inspection/Maintenance of Light Duty Vehicles in the Denver Air Quality Control Region, Nov., 1974.

26. U. S. Environmental Protection Agency. Control Strategies for In-Use Vehicles, Washington, D. C., Nov., 1972.

27. __________. (Office of Mobile Source Air Pollution Control). Print-out of 1976 Cert Vehicle Bag Analysis, Ann Arbor, Michigan, Feb. 4, 1976.

28. __________. Progress in the Implementation of Motor Vehicle Emission Standards through June 1974, Office of Planning and Evaluation, Washington, D. C., Dec., 1974.

29. __________. Supplement No. 5 for Compilation of Air Pollutant Emission Factors (second edition), Office of Air Quality Planning and Standards, Research Triangle Park, N. C., Dec., 1975.

30. Walsh, Michael P. Emission Factor Data, internal EPA slides prepared by Mobile Source Enforcement Division, Washington, D. C., 1975.

31. __________. Emissions Sensitivity Model, internal EPA memo to Norman D. Shutler.

32. __________. Impact of CARB Data on I/M Projections, internal EPA memo to Norman D. Shutler, Nov. 19, 1975.

33. __________. Tables on Inspection/Maintenance, inhouse data collection by Mobile Source Enforcement Division, U. S. EPA, Washington, D. C., 1975.

34. Wilder, Stephen F. An Evaluation of Emission Inspection for Taxicabs in New York City, Department of Air Resources, New York, New York, April, 1975.

35. Williams, Marcia E. Computer Simulation of Emission Inspection Procedures - Assessment of Effectiveness, (U. S. EPA),

36. __________. Model Description, U. S. Environmental Protection Agency, Ann Arbor, Michigan, 1975.

37. Zerbe and Croke. Urban Transportation Systems, Balinger Press.

PART B: COST AND FEASIBILITY

THE COST AND FEASIBILITY OF IMPLEMENTING INSPECTION MAINTENANCE

VI INTRODUCTION

A. The Issues

While acknowledging a number of uncertainties in the exact amount of HC reduction achieved by an inspection/maintenance program, the previous section of this report has concluded that I/M can be effective in reducing mobile source emissions. Two questions remain to be answered: What is the cost for achieving this emission reduction through inspection/maintenance? Given this cost effectiveness, what other kinds of factors influence whether I/M is a program that can be implemented?

The variable that seems to be most important in determining both cost and feasibility is the organizational structure used to implement I/M. Because of the importance of this variable, a description of the types of organization structure and the disadvantages and advantages of each are discussed separately in Part I.

The cost for I/M varies a great deal among existing programs. However, most of this variation can be accounted for by differences between the components and structure of the systems themselves and by differences in the price of certain system components at different locations. The cost components of I/M programs and the major reasons for their variation are discussed in Part II, "Costs Associated with the Implementation of Inspection Maintenance."

The true "consumer" of I/M systems is the vehicle owner who ultimately pays the program costs (via inspection fees.) and whose acceptance or opposition to the program influences how government officials view it. The evidence on car owner's response to I/M is conflicting. Surveys generally indicate that (s)he is willing to pay as much as a $5 inspection fee for an "air quality" related inspection.* However, there are a number of hidden costs, not covered by the inspection fee involving time and inconvenience incurred by vehicle owners participating in an I/M program. To date, no survey has captured and quantified the public's response to these costs. Actual operating experience has indicated a sometimes favorable, sometimes adamantly opposed response. These variables and their impact on I/M public acceptability are discussed in Part III, "Feasibility of I/M Implementation." Additional factors discussed in Part III are the existing institutional and legal frameworks available to implement I/M at national and state and local levels.

---

*See footnote 43

B. The Data Base: Strengths and Weaknesses

The principal data base for this section is information gathered from the six existing inspection/maintenance programs. These programs are located in:

Chicago, Illinois;
New Jersey (the only statewide program);
Cincinnati and Norwood, Ohio;
Portland, Oregon;
Maricopa and Pima Counties, Arizona; and
Riverside, California.

The data on these programs, compiled by State in Appendix A, include the following information:

1. institutional structure,
2. legislative history,
3. technical characteristics,
4. start-up costs,
5. operating costs,
6. consumer costs,
7. consumer protection, and
8. financing mechanisms.

This information was gathered to base the cost and feasibility analysis of I/M that follows in actual operating experience rather than in projections and estimates. Although experience provides the most reliable base for gauging political acceptability and estimating future costs, a word of caution about this data set is in order.

The data are quite preliminary. Only the Chicago and New Jersey programs have been in operation for more than a year. Neither the Arizona nor California programs begin fully mandatory testing until 1977. The effect of the programs' novelty on costs is to bias costs upward. There seem to be two elements causing the upward bias: the risk associatd with innovative ventures and, where programs begin on a pilot project basis, the diseconomies associated with small lot purchases of capital equipment.1/ An additional factor with a probable upward influence on costs is the amount

---

1/ Both kinds of influences are in evidence in California's program at Riverside. Apparently due to the uncertainty of a continuing lease, the contractor who leases the Riverside stations to the Vehicle Inspection program is amortizing his entire building investment over the two years for which he has a contract with the State. This has resulted in a leasing rate ($255,360/year) considerably higher than the one the contractor has agreed to should the program continue in his buildings ($85,020/year). Since equipment was purchased for only six lanes, prices were higher than they would have been had equipment been purchased for all the lanes planned.
Ref. 26, 28.

of learning involved in beginning any new program. 2/ The exact extent of this upward bias remains unclear. However, although preliminary, the data do represent what is in fact costing and what it does in fact take, institutionally and politically, to successfully implement inspection/maintenance programs.

There are two other potential sources of information on I/M's costs and feasibility: the demonstration programs financed by the National Highway Transportation Safety Administration at DOT and studies commissioned by EPA and certain States. Cost data from the NHTSA demonstrations will not be available until June of this year and are consequently not used in this analysis. Given the relative scarcity of I/M data from actual operation, this additional information will be of value to EPA. However, these demonstrations differ from the emission inspection programs recommended to States by the Agency in several important respects:

1) overall program size - small relative to any existing/planned I/M program, 3/
2) principal program mission - control of vehicle safety not emissions, 4/ and
3) costs to participating States and vehicle owners - virtually nil. 5/

These differences - which affect either cost or feasibility or both - should be kept in mind when reviewing the cost data the NHTSA program eventually will produce.

Cost data from EPA and State studies are summarized in Charts I - IV in Appendix B. In general, this information was not utilized in this analysis. There are several reasons for this. Both EPA and State studies present figures that are essentially projections, derived from

---

2/ The highest adminstrative start-up costs experienced by any existing program occurred in New Jersey. New Jersey was the first State in the country to have an operating I/M program. One can surmise that, at least in part, these high administrative costs reflect the "learning costs" for inspection/maintenance for the entire country.

3/ The NHTSA demonstrations involve roughly 12,000 LDV's per site as compared with the 142,000 LDV's in Riverside's pilot program, the smallest existing I/M program. Ref. 40

4/ Of the 75% of all participating vehicles generally flunked by the demonstration programs, only 20 - 25% are flunked for emissions-related reasons. Ref. 40

5/ NHTSA provides 90% of the funds needed to begin and run the programs while the States provide 10%, usually in in-kind services; no inspection fee is charged to vehicle owners and in several areas financial inducements, e.g., everything from green stamps to payment of repair costs, are offered to encourage vehicle owners to participate in the demonstrations. Ref. 40

extremely limited experience with actual program implementation. Comparing these cost figures to actual costs experienced by existing programs indicates that the studies have in general underestimated program costs by a factor of at least two. Secondly, although the State reports do capture some of the variations between regions for similar programs, the EPA figures represent only a kind of national average estimate. They fail to reflect the regional variations that do appear in the cost data from existing programs.

However, information from these studies was used as the basis for analyzing the costs of I/M systems with a private garage organizational structure. There are presently no existing I/M private garage systems, thus the study estimates provide the only private garage cost figures available.

VII. ORGANIZATIONAL STRUCTURE

There are three types of organizational structures that have been discussed/used to implement I/M:

1. centralized facilities operated by a government (as in New Jersey, Ohio, California, Oregon, and Illinois)
2. centralized facilities operated by a private, non-service industry corporation under contract to a government (as in Arizona), and
3. decentralized facilities operated by private service garages certified/licensed by a government (no decentralized emissions program presently exists).

Centralized programs take place in facilities whose only function is vehicle inspection. Decentralized programs take place in facilities whose principal function is generally vehicle servicing, not inspection. Due to the multi-purpose nature of decentralized program facilities, hence their much lower lane capacity for inspection, many more sites are required for decentralized than centralized programs. 6/

There are several important issues involved in choosing between these three system types: vehicle owner protection, vehicle owner convenience and program start-up time. These issues will be discussed briefly in this section. More detailed discussions of the impact of the choice of organizational structure on costs and feasibility is discussed in Chapters VII and VIII. In addition, Table 8 summarizes the advantages and disadvantages of each organizational structure.

6/ For example, in Denver, the number of inspection stations projected for a centralized idle mode system was forty-one. For the same number of vehicles, the number of service stations anticipated in the private garage, decentralized system was six hundred. (Ref. 12)

51

TABLE 8

ORGANIZATIONAL STRUCTURE: ADVANTAGES AND DISADVANTAGES

	Advantages	Disadvantages
Public Centralized	Consumer Protection: 1. Inspection separate from repair: no conflict of interest. 2. Independent basis for judging the performance of the service industry. 3. Monitoring of instruments' and inspectors' performance facilitated, thereby reducing testing variability. Cost: 1. Lower (inspection) labor costs, thus generally lower recurring costs. 2. More efficient use of equipment. Information: 1. Data collection facilitated. 2. Loaded mode testing possible.	Consumer Convenience: 1. Fewer inspection facilities, thus an increased probability of longer travel and wait times. Cost: 1. Start-up requires large public capital outlay. 2. All program costs born by public sector. 3. Risk of increasing long-term fixed costs to government due to increase in number of potential retirement/pension beneficiaries.
Private (Non-service industry) Centralized	Consumer Protection: } same as public Information: } centralized Cost: Same as public centralized, plus 1. All program costs born by private sector except those associated with administrative oversight. 2. No risks of increasing long-term fixed governmental costs. 3. Permits use of corporate tax structure to reduce burden of start-up capital expenditures	Consumer Convenience: Same as public centralized Consumer Protection: 1. Possible adverse public reaction to corporation earning profits from "captive market."
Private (Service industry) Decentralized	Consumer Convenience: 1. Greater number of facilities increases probability of minimizing travel and wait times. 2. Possibility for one-stop inspection/maintenance. Cost: 1. Lower start-up costs. 2. All program costs born by private sector except administration and monitoring.	Consumer Protection: 1. Inspection not separate from repair: presents potential for conflict of interest. 2. No independent basis for judging performance of service industry. 3. Effective monitoring of inspectors and instruments is more difficult. Cost: 1. Generally higher labor costs thus higher recurring costs. 2. Less efficient use of equipment. 3. Inspector training involves greater numbers and is therefore more costly. Information: 1. Uniform and detailed data collection is more difficult. 2. Loaded mode testing is improbable if not impossible.

A. Consumer Protection

The issue of consumer protection is involved in both the choice of system form (centralized/decentralized) and system "ownership" (public/private). Centralized systems, due to their higher inspection capacity per lane, involve many fewer inspection sites. The smaller number of sites allows for more effective monitoring of inspectors and equipment, thereby reducing test variability due to inspector and instrumentation variability. This in turn results in a decreased probability of error in measuring vehicle emissions. The smaller number of sites also means that a smaller total number of personnel are involved in providing inspections. Fewer personnel translates into lower inspector training costs.7/

A centralized system that is publically owned and operated offers two additional key consumer protection advantages: (1) an inspection process that is independent from the repair process and (2) an independent basis for judging the performance of the repair industry. Unlike centralized public systems, private garage I/M has both I/M elements - inspection and repair - taking place in one site. The lack of separation presents a potential conflict of interest: the "inspector" who determines whether or not your car must be repaired is also the mechanic who stands to gain some business from the mandated repair. Centralized systems that are privately operated seem to enjoy the same consumer protection advantages as public, centralized systems; however, this would only hold true insofar as the private corporation peforming inspections is disassociated with the repair industry. 8/ In systems where the private corporation was involved in the repair industry, public confidence could be expected to be low, reflecting the conflict of interest situation as well as the public's "universal distrust of mechanics."9/

B. Convenience

Convenience to vehicle owners is also a function of both system form and ownership.

The greater number of inspection sites in a decentralized system, while a disadvantage from a consumer protection viewpoint, offers two kinds of convenience advantages. Increasing the number of inspection

---

7/ In Denver a minumum of 600 personnel would be involved in inspections in the private garage system compared with 136 inspectors in the centralized system. Although per inspector training costs are estimated to be higher for the centralized system, total training costs for the centralized system are roughly 60% lower than for the decentralized system. Ref. 12.

8/ This is the case in Arizona where Hamilton Test Systems is under contractual obligation not to enter into the repair market in Arizona.

9/ Ref. 16, p. 133

stations within a given area increases the probability that a station will be found nearer to any particular vehicle owner's residence or work place, thereby tending to minimize the distance car owners must travel to receive an inspection. Secondly, the larger number of sites would seem to decrease the probability that any individual vehicle owner will spend time waiting in line for an inspection.

The private, service industry ownership of a private garage inspection program, while posing substantial ground for conflict of interest problems, also provides the potential for one-stop inspection/ maintenance. Instead of requiring that owners of vehicles that fail make three separate trips - to secure an inspection, to secure repairs and to secure a reinspection - a private garage system allows the vehicle owner the option of accomplishing all three tasks in one trip.

c. Start-up Time

Time required to put either a private or public centralized system in operation after the enactment of enabling legislation is roughly four years. 10/ Time estimated to put a decentralized program in place is roughly two years. 11/

Publicly operated centralized systems seem to involve the longest start-up time. Centralized I/M programs are capital intensive, requiring the purchase of buildings, land and equipment. Insofar as governments require competitive bidding procedures to be followed for each of these cost categories, the time required between legislation and actual operation is longer. Although private centralized programs do require involvement with these contracting procedures, they would seem to enjoy a slight time advantage relative to public systems since only one contract is let for the establishment of an entire system. 12/

Overall, of the three primary issues involved in the choice of organizational structures, vehicle owner protection seems to be the most important. Experience provides considerable evidence that, to date, the initial cost, operational and convenience disadvantages associated with publically and privately operated centralized systems are

---

10/ See Appendix A - State Profiles, Legislative History
11/ Ref. 16
12/ Evidence from experience is unclear on this point. Portland has taken approximately the same time to put in place a smaller considerably less capital intensive program than Arizona: in 4 years Arizona has put into operation a 37 lane system, with only one mobile van lane, serving 1.1 million LDV's; in the same time Portland has put in place a 15 lane system, with 1/3 of the lane capacity in mobile vans, serving 580,000 LDV's. California has put a smaller pilot system (6 lanes, 142,000 LDV's) into operation in 2 years using a sole source contracting procedure. The director of the program estimated that competitive bidding procedures would have added another 2 to 3 years to this time. Ref. 1, 6, 26, 38.
13/ Assuming an inflation rate greater than prevailing interest rates.

62

preferred to the risks of exposing the consumer to the increased probability of unnecessary and excessively costly repairs anticipated under a private decentralized system:

--all existing I/M programs are centralized;
--all the demonstration programs supported by NHTSA are centralized systems, despite efforts to conduct a private garage demonstration;
--one of the principal concerns of the Moodus Conference with respect to I/M was consumer protection, 15/ and
--50% of all vehicle owners being reinspected by private garages in New Jersey return to State lanes for a second reinspection, presumably to certify the testing results of the service stations. 16/

Consumer protection seems to take clear precedence over convenience and quick start-up times for both government and vehicle owners.

VIII. COSTS ASSOCIATED WITH THE IMPLEMENTATION OF INSPECTION/MAINTENANCE

A. Introduction

The costs discussed in this section are financial costs incurred as a direct result of I/M implementation. These cost categories are:

A. start-up costs - land, buildings equipment;
B. recurring costs - salaries, fringe benefits, overhead, leasing; and
C. vehicle repair costs.

Although start-up and recurring costs are funded by governments in all existing case examples, it is the vehicle owner who ultimately pays for the I/M system with his(her) inspection fee. In addition to the inspection fee, operators of vehicles that do not pass inspection pay out-of-pocket for the costs of repairs.

14/ Extremely limited experience with private centralized systems indicates that this system type shares the consumer protection advantages of public, centralized systems.
15/ Ref. 14
16/ New Jersey instituted a system of reinspection by private garages in the hopes of decreasing the congestion occurring due to limits on its system's capital expansion. Private garage reinspection would have convenience advantages similar to private garage inspection. Nonetheless, public mistrust of the private garage industry seems to be such that 50% of flunked vehicle owners return to State lanes for a second reinspection. Ref. 13

There are several program characteristics that seem to determine the total amount of expenditure needed in the first two cost categories. These program characteristics are:

1. the program's organizational structure,
2. the mode and type of testing used, and
3. the program's location.

Organizational structure, as discussed above, determines a number of program variables that affect consumer acceptability. In addition, organizational structure seems to affect the total amount of direct program cost and how this cost is distributed among the different cost categories and among the different program participants.

The type of inspection may be an emissions-only inspection or an emissions and safety inspection.17/ The test mode may be idle or loaded.18/ Both test type and mode affect program characteristics, throughput rates in particular, that determine the total system size needed to inspect a particular vehicle population. There is some evidence to indicate that test mode also influences repair costs. This aspect of the test mode is discussed in the political feasibility section. Finally, the program's location affects certain cost categories subject to regional variation, e.g., inspector salaries. In the following section each type of cost will be discussed in terms of these three program characteristics. Although the cost data from the existing programs are difficult to compare,19/ an attempt will be made to analyze the relationship between these program variables and costs.

B. Start-up Costs

Start-up costs include expenditures for capital investments in land, buildings and equipment and adminstration. Existing programs provide sufficiently detailed data on capital costs (see Table 9) to make comparisons between programs possible, although the components of start-up administration for each program are unique, making comparisons tenuous a best.20/ Looking at the three capital cost categories, building costs tend to be the most expensive single category. However, due to leasing arrangements in three programs and an unusual cost break-out in another, it is difficult to talk about relative percentage ranges for each start-up category. Within these limits it is possible to discuss the general direction of the effect on start-up costs of the three program variables.

17/ Emissions only: California, Portland, Arizona and Chicago.
Emissions and safety: New Jersey and Cincinnati

18/ Idle: New Jersey, Chicago, Cincinnati and Portland
Loaded: Arizona and California

19/ Due to the unique characteristics of each program

20/ Administrative costs include some or all of the following: public relations, mechanic/inspector training, extensive laboratory work to determine testing standards, studies to determine station locations and detailed program plans.

TABLE 9

CAPITAL COSTS FOR EXISTING PROGRAMS

Location	Organizational Structure	Test Type	Test Mode	# Lanes	Administration	Equipment	Buildings	Land	Total
New Jersey	State Owned and Operated	Safety and Emissions	Idle	68	$2,400,000	250,000	25,500,000[a]	4,800,000[a]	$32,950,000 485,000/ lane
Cincinnati and Norwood, Ohio	City Owned and Operated	Safety and Emissions	Idle	4	None accounted for	600,000[a]		200,000-400,000	800,000-1,000,000 200,000/ land
Chicago	City Owned and Operated	Emissions	Idle	18	600,000	1,250,000	460,000[f]	460,000	3,840,000 213,300/ lane
Portland, Oregon	State Owned and Operated	Emissions	Idle	15	800,000[d] Financing: 15,750[e]	203,000	107,750[b]	74,000[c]	1,200,500 80,000/ lane
Riverside, California	State Owned and Operated	Emissions	Loaded	6	450,000 Financing: 320,000[e]	580,000	Leased		1,350,000 225,000/ lane
Maricopa and Pima Counties, Arizona	Franchise	Emissions	Loaded	37	1,132,000	3,000,000	3,600,000	1,400,000	9,132,000 247,000/ lane

a. Estimated Replacement Value
b. 1 permant building and six mobile vans
c. Estimated Value - Actually leased for $1/yr. from State Highway Department
d. Includes 18 months operation costs for pilot program
e. To date
f. Includes cost of 12 vans
g. Rough estimate of value - land previously owned by city so acutal expenditure = $0.

o Effects of Organizational Structure o

A program's organizational structure determines in which cost categories start-up expenditures occur and what sector bears the burden of these costs. Centralized programs involve large expenditures in all three capital cost categories - land, buildings and equipment. In centralized public systems these expenditures are the responsibility of government. In centralized private systems, the inspection corporation bears this expense. In decentralized private systems, the only capital expense involves equipment. The equipment is procurred by private garages participating in the I/M program. Although start-up expenses are incurred in all capital cost categories for centralized systems, the considerably greater number of analyzers needed in decentralized systems seems to almost entirely offset this effect. For the same vehicle population, centralized systems incur capital costs only slightly larger than capital costs estimated for decentralized systems. (See Table 10)

o Effects of Test Type and Mode o

Test type affects total flunk rates and throughput rates. A test for emissions and safety typically flunks a higher percent of all vehicles inspected and takes longer on average than does an emissions only test. Consequently, an emissions and safety test will require greater lane capacity than an emissions only test, given the same vehicle population. In centralized systems this translates to more/larger facilities which means increases in all capital cost categories. In decentralized systems, the need for greater lane capacity translates to increases in the number of service stations participating in the program, with consequent increases in equipment costs.

Loaded mode tests require an additional piece of equipment, a dynamometer, beyond the analyzers required for idle tests. Thus, the test mode effects the per lane cost of equipment and so the total expenditure in that category. In addition, the test mode affects throughput rates - loaded mode tests take longer to administer than idle tests 21/ - which in turn affect the amount of lane capacity needed to serve a particular vehicle population. Thus, for centralized systems, a loaded mode means not only higher equipment costs but higher land and building costs as well. A private garage organizational structure precludes loaded mode testing. 22/

21/ Ref. 12, 23; in addition, compare, for example, California (loaded) to Portland (idle) test times.

22/ This is a generally agreed upon point, primarily because of the expense and special spatial arrangements required for loaded mode tests although the Denver study provides estimates for a private garage loaded mode inspection. Ref. 1.

64.

TABLE 10

COMPARISON OF STUDY ESTIMATES OF START-UP AND RECURRING EXPENDITURES FOR DECENTRALIZED AND CENTRALIZED I/M SYSTEMS

Source	#LDV's	Decentralized Start-Up	Decentralized Recurring	Centralized Start-Up	Centralized Operating
EPA, OTLUP '75	1 million	$2,225,000	$2,200,000	$1,492,800[a] - 3,542,000	1,600,000
Batelle '75	32,000	333,920[b]	1,600,000	43,900 - 108,360	50,000
Denver '74	896,000	2,662,000	4,442,000	3,195,100	2,600,000

a. Assuming a throughput of 32,000 LDV's/lane/yr., 32 lanes will be needed to inspect 1,000,000 LDV's.
b. Assuming 32 stations with 1 inspection lane each.

NOTE: All estimates are for idle mode, emissions only testing.

o Effects of Program Location o

The effect of location on centralized programs' capital costs 23/ is difficult to discern from the available data. It is certain that there is considerable variation in the price of land and construction for existing stations between regions. 24/ However, there is within any particular metropolitan area considerable variation in the price of land, more densely populated zones being more expensive than less densely populated zones. Thus, it is virtually impossible to determine the extent to which land price variations between regions reflect a different scattering of stations, that is intrametropolitan land price differentials. However, station locations and consequently the average land price for any particular system would depend on the density, transportation and demographic characteristics of that particular area. Insofar as density, transportation systems and demography vary between metropolitan areas in different regions (e.g., Northeast and West), the average price for land for inspection stations would also vary. There is even less comparative data available on building costs. What is available suggests that construction costs are also subject to the same sort of intrametropolitan variation, and so overall variation between regions with different land use characteristics. 25/

In a general way, the influences of organizational structure, test type and mode, and location on start-up costs are borne out be experience. The most expensive centralized system, New Jersey's, is a combined emissions and safety inspection occuring in a highly urbanized State where wage rates and land prices tend to be high. The least expensive system, Portland's, involves an idle mode, emissions only inspection in a considerably less urbanized State. 26/

c. Recurring Costs

Recurring costs present considerably fewer problems in comparing cost categories across programs. Recurring costs for existing programs are summarized in Table 11. Annual budget information, which is readily available, tends to be broken down into similar categories: labor and "other." The primary component of recurring costs is labor,

---

23/ Decentralized programs, using already existing facilities avoid land and construction costs.

24/ The value of the land on which Cincinnati's inspection station is built is $.92/square foot; in Portland, $2.75/square foot; and in Newark, approximately $3.00/square foot. Ref. 34, 37, 39.

25/ Per lane construction costs for a station in relatively rural South Jersey were $160,000; for a station in highly urbanized Newark, $500,000. Ref. 34.

26/ However, this cost differential is also due to Portland's management of its capital costs. Only one of Portland's stations has been constructed. Four are leased and the remaining six "stations" are mobile vans. Mobile vans cost less than permanent stations not only because of the relatively lower costs of vans versus buildings, but also because vans allow a program to avoid expenditures on land by "camping out" on under-utilized but already developed land, e.g., shopping mall parking, abandoned used car lots, school parking lots in summer, etc.

66.

TABLE 11

RECURRING COSTS FOR EXISTING PROGRAMS

Location	Organizational Structure	Test Type	Test Mode	# Lanes	Administration	Inspection	Other	Total
New Jersey	State Owned and Operated	Emissions and Safety	Idle	68	Gross Salary: $426,000 Fringe: 106,500	Gross Salary: 491,176 Fringe: 1,872,941 PPO: 300,000[d]	Lease: 200,000 Overhead, Supplies: 850,000	11,236,617 165,240/lane
Cincinnati, Ohio	City Owned and Operated	Emissions and Safety	Idle	4	385,000[a]		Non-Personnel: 50,000 Special: 100,000[b]	535,000 133,750/lane
Chicago	City Owned and Operated	Emissions	Idle	18	160,224[a]	819,264[a]	"Goods and Services" 600,000	1,579,488 87,750/lane
Portland Metropolitan Service District, Oregon	State Owned and Operated	Emissions	Idle	15	Gross Salary: 126,000 Fringe: 21,042	Gross Salary: 703,500[c] Fringe: 117,485	Lease: 81,600	1,049,600 70,000/lane
Riverside, California	State Owned and Operated	Emissions	Loaded	6	Gross Salary: 169,344 Fringe: 27,942	Gross Salary: 356,808 Fringe: 58,873	Lease: 255,360 Equipment Replacement 100,000	968,300 161,390/lane
Maricopa and Pima Counties, Arizona	Franchise	Emissions	Loaded	37	350,000HTS[a] 330,000Ariz.	3,700,000[a]	Public Relations 250,000	4,630,000 125,135/lane

a. Including fringe

b. Includes some unusual expenses, e.g., photographic equipment and supplies used to document "unroadworthiness" of cited vehicles.

c. Gross salary for 75 employees in a reregistration year; for an off year when only cars changing registration are required to be inspected, there are 27 inspection staff: Gross salary $272,484/year; fringe: $45,505/year

d. PPO = Premium Portion of Overtime: like fringe benefits, this is not accounted to either the DEP or DMV budget, but is paid directly out of the New Jersey State Treasury.

ranging between 63 to 90% of total recurring costs, with California at the lower end of the spectrum and New Jersey at the top. The remaining 10 - 37% of operating costs are incurred for overhead and leasing expenses. New Jersey leases 13 of its 38 sites, Portland four of its five permanent sites, and California both of its present two Riverside sites.

These labor costs include fringe benefits and cover a variety of program tasks - public relations, data collection, equipment maintenance and repair, general administration and inspection. However, the largest portion of these costs is in the inspection function - in Arizona roughly 75% of total operating costs as compared with 10% for administration and public relations, in Portland 78% for inspection as compared to 14% for administration. [27] Each of the three program characteristics discussed above effects the principal component of recurring costs, labor.

o Effect of Organizational Structure o

There is little data available on the effects of organizational structure on labor costs since there are no existing private garage systems. However, the limited data available suggest that centralized systems can expect lower total labor costs than decentralized systems. [28] The principal reason for this difference lies in the different wage rates for the "inspector" in each organizational structure. Station inspectors in a public system earn approximately $4.75 - 5.00/hour, whereas private garage mechanics, the inspectors in a decentralized system, earn an estimated $6.50 - 12.50/hour. [29] This wage differential is an immediate cost advantage of centralized systems. However, since governments pay the salaries of employees in a public centralized system, this short-term advantage would seem to be at least partially offset by the increased risks of long-term fixed obligations associated with civil servant pensions. Both centralized and decentralized private systems avoid this risk by shifting fringe benefit responsibilities onto the private sector.

o Effect of Test Type and Mode o

The influence of test type and mode on labor costs is fairly straightforward. Insofar as the choice of test type and mode affect certain program characteristics (flunk rate and throughput rates) which in turn determine the total number of lanes needed to serve a particular population, test type and mode effect the total number of inspectors needed. Where flunk rates are high and throughput low, more lanes are needed and consequently, assuming a relatively constant inspector/lane ratio, more inspectors. [30]

---

[27] "Administration" in Portland includes three field supervisors. Ref. 39.

[28] Ref. 12 and 16.

[29] Ref. 12 and 16.

[30] In addition, the Denver report uses higher inspector wage rates for a loaded mode test than for an idle mode. However, a wage rate effect of test mode is apparent in no other data. For purposes of this report this effect will be considered to be nil. Ref. 11.

o Effect of Program Location o

Program location seems to affect two components of labor costs: gross salary and fringe benefits. Public sector salaries vary by region with Northeast and North Central regions experiencing generally higher public sector wage rates than the South and West. 31/ Fringe benefit expenditures, not an inconsiderable portion of total labor costs, seem to experience somewhat greater variations than salaries, ranging from 30% of gross salary in New York to 12% of gross salary in Chicago. 32/ These rates also seem to vary according to the same regional patterns as wage rates, thereby accentuating the regional variations in total labor costs.

o Enforcement Costs o

A final note on operating costs: no programs nor estimates include in their tabulation of recurring costs the expenses associated with enforcing the program. An estimate of this expense can be calculated by taking the number of citations issued to non-registered or uninspected vehicles, multiplying this figure times the percent of non-registerations and non-inspections due to emissions and then multiplying this by the costs associated with issuing a citation. However, these costs seem insignificant relative to total recurring costs. 33/

31/ Ref. 7. Wages for New Jersey inspectors tend to be somewhat higher ($11,233/year) than inspector wage rates in either Cincinnati ($9,893/year) or Portland ($9,024/year). Ref. 34, 35, 39.

32/ Fringe benefits as a percent of gross salary:

New York - 30%	Portland - 16.7%	Ref. 23, 28, 31
New Jersey - 25%	California - 16.5%	34, 38, 39
Cincinnati - 25%	Chicago - 12%	

33/ A "guestimate" of this figure was provided by the New Jersey program:

1. Total summons/year issued for out-of-date or rejected inspection stickers = 12,000
2. Percent of inspection rejections due to emissions (Phase II) = 36%
3. Citations issued for emissions = 4,320
4. Figuring a rate of 2 - 3 summons issued per hour and per hour costs per salaries, uniforms, vehicles, etc., a rough estimate of per/citation costs = $20
5. Total costs for emissions enforcement = $86,400/year. This turns out to be .8% of the total recurring costs of the New Jersey program, hardly a significant figure. Ref. 34.

A similar calculation for Cincinnati resulted in a much higher enforcement cost estimate: 25 - 33% of total annual recurring costs. The size of this figure relative to New Jersey's is due to a vastly larger number of citations issued (89,598 citations for safety lane violations in 1974) and an emissions flunk rate that is responsible for 60% of all vehicle inspection failures. Interviews with program staff in other States seems to indicate that Cincinnati's experience is atypical.

As in start-up costs, actual operating experience tends to bear out the relationships between the three program variables and recurring costs. Portland, the program with the most minimal test (idle mode, emissions only) located in a region with low public sector wage rates and low fringe benefits experiences the lowest per lane operating costs. New Jersey, the area with the highest wage rates, one of the highest fringe rates and a safety and emissions program, experiences the highest per lane operating costs.

D. Repair Costs

Unlike other financial costs directly associated with I/M implementation, emission related repair costs do not seem to vary by organizational structure, test type or program location. There is some very preliminary information that indicates a relation between repair costs and test mode. This issue is discussed further in the Flunked Vehicle Costs Section of Part III. This portion of the report discusses how much it has actually been costing vehicle owners to pay for repairs secured as a result of participating in an I/M program and what percent of these costs can rightly be attributed to emissions inspection.

Data on repair costs is presently available from four of the existing six programs: New Jersey, Portland, California, and Arizona. Average repair costs for these programs range from $16 to $32/flunked vehicle. Recent data from California indicate that these costs might be as much as 50 - 100% higher for catalyst vehicles: 33 catalyst vehicles participating in the Air Resources Board Motor Vehicle Inspection Program Evaluation experienced repair costs averaging $30 - 40 per vehicle. 34a/ However, average figures are somewhat misleading. The distribution of maintenance costs for three of the programs is weighted toward the lower end. (See Table 12-no distribution data are presently available for California). This distribution is in part a reflection of the percent of vehicles flunked for CO as compared to HC since, in general, a higher proportion of vehicles are flunked for CO violations 34b/ and repairs for CO related failures tend to be less costly. 35/

An important issue surrounding these apparently straightforward costs is the extent to which they can be directly attributed to inspection/maintenance. This depends on the relative frequency with which tune-ups are performed with and without I/M. For example, all existing I/M programs except Portland's perform inspections on an annual basis. If vehicle owners ordinarily have their cars tuned up every two years, then only half of all repair costs can be attributed to I/M since half of these repairs would have been done in any case. The evidence on actual tune-up frequencies is quite limited. Champion Spark Plugs has surveyed vehicle owners and found that 76.6% have tune-ups performed at least annually. 36/ However, the vehicles that fail to pass an emissions inspection are likely to be

---

34a/ Ref 20a.

34b/ New Jersey: CO - 50% Portland: CO - 70% Arizona: data not yet available
HC - 30% HC - 11%
CO & HC - 8% CO & HC - 10%
Ref. 32, 39, 40.

New Jersey	Portland	Arizona
CO - 50%	CO - 70%	data not yet available
HC - 30%	HC - 11%	
CO & HC - 8%	CO & HC - 10%	

Ref. 32, 39, 40.

35/ In Portland in January 1976, 15% of a sample of 140 LDV's failing the emissions test failed for HC and 72% for CO. These two groups experiencede following repair costs:

	HC	CO
No Charge	17%	19%
0 - $10	17%	45%
over $100	16%	5%

Ref. 40.

36/ Ref. 3

TABLE 12

REPAIR COSTS FOR EXISTING PROGRAMS

New Jersey (flunk rate = 12%)

less than $10	29.7%
$10 to $25	26.4%
$25 to $50	22.1%
$50 to $100	16.1%
more than $100	5.6%

N = 16,000
Avg. Repair Cost = $32.40
Median: 50% of repairs cost less than $20
65% of repairs cost less than average

Oregon (flunk rate = 35%)

No cost	27%
less than $10	37%
$10 to $30	18%
$30 to $50	8%
$50 to $75	5%
more than $100	2%

N = 1,400 (primarily newer cars)
Avg. Repair Cost = $16.00
Median: 50% of repairs cost less than $8
71% of repairs cost less than average

Arizona (flunk rate = 47%)

less than $5	24%
$5 to $10	20%
$10 to $25	29%
$25 to $50	18%
$50 to $100	7.5%
more than $100	1.5%

N = 500 (does not include those who performed their own repairs)
Avg. Repair Cost = $19.95
Median: 50% of repairs cost less than $15
66% of repairs cost less than average

Ref. 14

those vehicles that are tuned up least often in any given vehicle population, 37/ using Champion's figures, the 23.4% with tune-up intervals greater than a year. In order to discriminate repair costs occurring solely as a result of I/M, it is necessary to know the average tune-up interval of vehicles with tune-up intervals greater than one year. The only information available on this average suggests that it is twenty-two months. 38/ Given the above assumptions and that most inspection programs have flunk rates of 30% or less, it is fair to assume that those flunked are primarily the 23 - 30% with average tune-up intervals of 22 months. Thus, I/M related repair costs would be roughly half the repair costs actually experienced by vehicle owners.

Financing

The three major cost categories of inspection maintenance programs - start-up, recurring and repair costs - each have different means of financing. The financing methods for each cost category except repair costs vary depending on the program's organizational structure.

Cost associated with start-up have been financed, in centralized public systems, through the current budgets of the concerned level of government. The monies needed to establish the I/M program have either been appropriated directly to the vehicle inspection program or the vehicle inspection program has borrowed the money from another State department (California). Although experience with private centralized systems is quite limited to date (one case example), it seems that such systems have a capacity to use the corporate tax strucuture to cover such capital expenditures over time. Such an arrangement effectively shifts the burden of financing the capital investment for inspection/maintenance from State to Federal shoulders. There is no data available on financing mechanisms for the capital investment required in private garage systems. 39a/ However, assuming that the capacity to write-off capital expenditures is a function of type of ownership, private decentralized systems would share in the same financing advantage as private centralized systems. Like start up costs, recurring costs in both public and private centralized systems are also financed from current
State budgets.

37/ Assuming either straight line or concave deterioration curves. See Section Part for further discussion of this issue.

38/ Ref. 24, p. 49 (Zerbe, Croke) NOTE: this same source also suggests that 30% of all vehicles have tune-up intervals longer than 1 year.

39a/There are no existing private garage I/M systems. None of the available reports address this question. The assumption seems to be that the equipment purchase is regarded by the private garage owner as an investment in increased business.

73.

The important point to note about these financing arrangements is that the State gets the money to pay for operating expenditures from the revenues generated by the inspection fee. (See Table 13) In centralized public systems, the fee may also be used toward payment of the original capital investment. Because I/M is a fee-financed program, the considerable costs required for implementation basically pose no problem. From the point of view of State legislators/city councilmen, inspection/maintenance is not a deficit - producing program and, in fact, because of its revenue generating capacity, may be a deficit-reducing program, clearly a positive feature.

Repair costs in all systems are financed directly by the vehicle-owning public. The Clean Air Act in Section 207(b) clearly intends that the automotive manufacturers bear these costs during a vehicle's first 50,000 miles, provided vehicle owners do their part and maintain their vehicles. Although this would not cover the total I/M repair bill, it would pay some or all of the I/M-associated repair costs for vehicles with mileage less than 50,000, approximately 40% of all vehicles. 39b/ However, in the absence of a short test that is highly correlated with the FTP, such performance warranties cannot be implemented. For the forseeable future the vehicle-owning public will continue to be the sole financier for the total I/M repair bill.

39b/ AP 42

74.

TABLE 13

TOTAL PROGRAM COSTS AND REVENUES FOR 3 EXISTING PROGRAMS

Location # Vehicles	Test Type Mode Flunk Rate	Lanes	Start-Up	Recurring Annual	Revenue from Inspection Fees[a]	Total Repair Estimated[b]
New Jersey 3,800,000	Safety and Emissions Idle 18%(Emissions)	68	$32,950,000	$11,236,617	4,400,000	$14,774,400 7,387,200
Maricopa and Pima Counties, Arizona 1,100,000	Emissions Loaded 47%	37	9, 132,000	4,630,000	5,500,000	10,314,000 5,157,000
Portland, Oregon 580,000	Emissions Idle 35%	15	1,200,500	1,049,600	2,900,000	3,248,000 1,624,000

a. Inspection "Fees": New Jersey - $1
Arizona - $5
Oregon - $5

b. **NOTE:** Figure in top box for each area is the total amount of repair costs experienced; the figure in the lower box is the amount of that total that can be directly attributed to I/M. (See discussion of repair costs in Section II.)

'76<

E. Summary

The answer to the question posed at the beginning of this section - what does it cost to implement inspection/maintenance - is that costs vary, but are generally quite large relative to State/local expenditures for air/environmental programs. 40/ Variations in direct program costs can be attributed to three program characteristics: organizational structure, test type and mode, and program location. The exact amount of variation due to each of these factors remains unclear. However, the direction of each variables's influence on costs is readily discernible from the information available. The following relationships have been observed.

- Although experiencing somewhat higher and certainly more visible start-up costs, centralized systems experience considerably lower operating expenditures than decentralized systems. Consequently, centralized systems are, overall, less costly than decentralized system.

- Combined emissions and safety testing is more costly than emissions only testing in terms of both capital and operating expenditures.

- Loaded mode testing is more costly than idle mode testing in terms of both capital and operating expenditures.

- Programs located in metropolitan areas in the Northeast and North Central regions of the country will tend to be more expensive in both capital and operating cost categories than programs located in the South and West.

Despite the relatively large size of expenditures required for I/M implementation, no major difficulties have been encountered to date in financing the program. Start-up costs have been financed via State/local current capital budgets or loans. Recurring costs have been financed through State/local current operating budgets. However, the ultimate financier of the program is the vehicle owner who directly underwrites both capital and operating budgets with his(her) inspection fee.

In addition to ultimately paying the bill for start-up and operating costs, the vehicle owner also pays the I/M repair bill. Both the inspection fee and the repair costs are highly visible costs that come directly out of the consumer's pocket. Inspection/maintenance is critically dependent upon the support of the vehicle-owning public. Consequently, I/M's success as an air quality management strategy seems to depend less on the program's cost per se and very much more on the program's political feasibility, costs being only one component of political feasibility. The political feasibility of I/M is addressed in the next section.

40/ OPE report in progress

IX. POLITICAL FEASIBILITY OF IMPLEMENTING INSPECTION/ MAINTENANCE

A. Introduction

Political feasibility refers to the probability that inspection/maintenance will become an actual on-going program in the eighteen States where it is presently part of the State Implementation Plan. Two kinds of factors determine this probability:

A. the program's general market acceptability and
B. the existing legal and institutional situation.

A. Inspection/maintenance has a number of direct and indirect impacts on several sectors and consequently a variety of "markets." Indirect impacts can be anticipated on the aftermarket parts industry and, insofar as I/M affects the scrappage rate, on the automobile industry as a whole. Direct impacts will be experienced by the automotive service/repair industry and the vehicle-owning public. This analysis will focus on the acceptability of I/M to the vehicle owning public. Vehicle owner acceptability will be examined in light of the three kinds of "expenditures" required of vehicle owners participating in an I/M program. These expenditures are:

1. the inspection fee,
2. the price of necessary repairs and
3. the time and inconvenience costs associated with securing inspections and repairs.

B. The existing legal and institutional framework will be discussed from both a national and a State/local perspective. On the national level, the single most pressing legal question concerns EPA's authority to enforce inspection/maintenance in the States. On the State and local level, two factors affect I/M s political feasibility:

1. whether or not the State/locality has legislation which enables it to implement an I/M program, and
2. whether or not there is an existing periodic motor vehicle inspection program (PMVI) in the implementation area, and if so, the organizational structure of that PMVI.

B. Vehicle Owner Marketability

The question addressed in this part is whether or not the costs to vehicle owners participating in an I/M system are experienced by them as excessive. Data on the three consumer costs involved in I/M - - inspection fees, repair costs and time and inconvenience costs - is generally limited. The amounts charged for inspection are known. Existing programs have collected data on the experienced costs of repair. However, quantifiable estimates of the time and inconvenience costs are non-existent. Market data is available only for inspection fees. Given these constraints, the goal of this section is to provide a "feel" rather than a "figure" for the costs to vehicle owners.

The first point to note about these costs is that they are distributed unevenly among vehicle owners. Owners of vehicles that pass the inspection pay the inspection fee and experience the time and inconvenience costs involved in actually going and getting an inspection. Vehicle owners whose cars flunk the inspection pay the same fee and time costs as owners of passing vehicles, plus the repair bill, plus the time and inconvenience costs involved in securing the repairs, plus the time and inconvenience costs associated with securing a reinspection.[41]

o Inspection Fees o

For owners of vehicles that pass, the principal cost seems to be the inspection fee. Inspection fees are set to recoup start-up and cover operating costs. For presently operating programs, these fees range from $3.75 to 5.00.[42] The limited evidence available on the market acceptability of inspection fees suggests that the reasonable maximum fee is $5.00. [43]

o Time and Inconvenience o

There are other more varied costs incurred by owners of passing vehicles in terms of time and inconvenience:

41/ In general, no fees are charged for reinspection.

42/ This does not include New Jersey, where the fee is $1 for the first inspection (included in registration fee) and $1 for reinspection. Unlike the other programs' fees, New Jersey's one dollar is not designed to cover costs, but was determined by the history of the program and New Jersey politics. However, the State Legislature has recently passed a bill raising the initial inspection fee to $2.50/vehicle. Ref. 32, 34.

43/ A survey done in Houston, Texas, in 1972 found that $5.50 was generally judged to be a "reasonable" inspection fee for an I/M program designed to reduce air pollution. Two public opinion surveys were done in Denver, Colorado, in 1971 and 1972. The first survey found that 54% of the respondents wanted a fee less than $3.00. One year later, what respondents were willing to pay on average was $4.50. The chief uncertainty underlying these figures is that in general, figures found theoretically "reasonable" are often found "unreasonable" in practice, when it comes time to pay. Ref. 12, 16.

1. time traveling to and from the inspection station,
2. time spent waiting in line to be inspected,
3. time spent undergoing the inspection process and, in States where there is no existing PMVI,
4. the general inconvenience of accustoming oneself to a new behavior.

There is basically no data available to calculate a reliable estimate of the first and last costs. The data available on wait times suggests an overall average wait time of 15 minutes, with a range of 0 to 3 hours. The inspection process itself is much more stable and takes roughly 5 minutes or less for an idle test and 7 minutes or less for a loaded test. Using a conservative estimate of $5.00/hour to value this time, 44/ the additional cost to vehicle owners over and above the inspection fee is, on the average, $1.67 for an idle test and $1.83 for a loaded test.

The wide range of wait times implies a risk associated with inspection/maintenance. Although a vehicle owner may reasonably expect an additional $1.67 worth of wait cost, (s)he also runs a risk of paying no additional cost or as much as $15 worth of his(her) time. The upper limits of this range seem clearly unacceptable. However, it remains unknown at what point the expected (average) time costs begin to add an unacceptable burden to the fixed cost of the inspection fee. 45/

o Flunked Vehicle Costs o

Owners of vehicles that flunk - from 18% to 47% of all vehicle owners - pay the above costs and in addition, the following:

1. the repair bill,
2. the time and inconvenience costs associated with securing the repairs, and
3. the time and inconvenience costs associated with securing a reinspection.

Time and Inconvenience

The time and inconvenience costs involved in securing a reinspection are assumed to be equal to those involved in securing the first inspection. The time and inconvenience costs associated with securing repairs involve time

---

44/ Since the majority of inspection visits are made during or as part of the regular work day, the most appropriate value for this time would be equivalent to the "average" worker's wage rate. There are varied estimates of this rate ranging from $2.50 to $6/hour. Variations are due to the method used to calculate the wage rate, as well as the geographical area for which the calculation is made. For the purposes of this analysis, a conservative estimate of $5/hour will be used.

45/ The surveys mentioned in footnote 43 all asked questions about the inspection fee. Whether or not respondents included their time costs in this evaluation remains unclear.

traveling to and from the repair station, time spent at the repair station explaining, hearing explanations, waiting, and paying the bill, and the time and inconvenience involved in securing other modes of transportation or forgoing trips that otherwise would have been made. 46/ There are no available estimates of these repair-associated time costs.

Repairs

Data is available on the costs of repair. This information indicates, as discussed in Part II, Chapter VII. that average repair costs range from $16 to $32 with approximately two-thirds of all vehicle owners paying less than this average amount. There are two program variables that are thought to affect repair costs by increasing the accuracy of emissions-related repairs: mechanic training and test mode.

Programs to promote emissions training for mechanics exist on both the national and state level. 47/ The rationale for mechanic training is that

---

46/Assuming that the vehicle owner deposits the car at the service station leaves to go about other business and returns when (s)he expects that the vehicle will have been repaired.

47/ EPA and HEW have signed an interagency agreement to transfer $100,000 of EPA monies to HEW's Office of Educaton. The Office of Education is responsible for distributing the money through its vocational education system to develop emissions training for mechanics in the five States designated in the agreement (New York, Pennsylvania, California, Oregon and Arizona).

In addition to the interagency agreement, HEW and EPA are working cooperatively on the development of an emissions training program for master mechanics. The program will involve approximately $370,000: $150,000 from the HEW Office of Education and State Departments of Vocational Education, and the remaining $220,000 from EPA. It will proceed in two phases: in June and July of this year two regional meetings to train 40 master instructors from 20 States will be held; as a condition of this 2-week training, these 40 instructors will return to their States and each train roughly 20 additional "emissions instructors."

Complementary to this effort, mechanic training has been attempted in two of the six areas where I/M exists: New Jersey and California. In 1972 in New Jersey, 4,000 mechanics participated in an emissions training program offered by the State. New Jersey also reports that Exxon has done some emissions training of their service station personnel, affecting approximately 15% of all New Jersey stations. In California mechanics doing repairs for vehicles participating in the inspection program must have a Certificate of Qualification. For "installer adjusters," a special category of mechanics licensed by the State to install and adjust pollution control equipment, this is obtained by attending a State sponsored, 8-hour workshop. For unlicensed mechanics, the certificate is obtained by attending the workshop and then passing a written exam. Ref. 2, 27, 32.

50.

without it "resultant emissions reduction from the (I/M) program would be quite small and the cost of the tune-up and repair work would be quite high."48/ Mechanics uninformed about emissions tune-ups apparently make excessive repairs 49/ in an effort to hit on the causes of the emissions problem. By improving their understanding of the relationship between emissions and engine malfunction, the accuracy of their repairs is thought to be improved, directly lowering the repair cost. The major assumption in this line of reasoning is that emissions training improves the accuracy of emissions-related repairs. To date, this connection between training and repair accuracy has not been well documented.

Test mode affects the extent and kind of information provided to owners of flunked vehicles (and so to mechanics) about the reasons for a particular vehicle's failure. A loaded mode test provides considerably more information than anidle test. However, whether or not this additional information actually improves emissions repairs depends on the service industry's ability to use the information. There is conflicting evidence to date on this point. EPA studies indicate that this additional information, coupled with instructions on how to use it has a significant impact on reducing the frequencey of excessive repairs. 50a/ More recent data from the California MVIP Evaluation indicate that, at this time, the service industry does not have the emissions sophistication needed to put the additional diagnostic information to use. In fact, it seems that the additional information serves to confuse rather than enlighten: although the average cost of repairs for vehicles participating in the loaded mode "regime" was not significantly different from the average cost of repairs on idle regime vehicles, the loaded regime repair involved an average "procedural overcharge" (charge for unauthorized repairs) double that of the idle regime. 50b/

It is clearly important to reduce excessive repairs so that vehicle owners will have to pay no more than necessary. This is especially true for that portion of vehicle owners paying repair costs in excess of $100. Although the group bearing these extremely high costs is small relative to the total number of vehicles flunked, it is nonetheless a group of sufficient size to constitute a potential source of significant political opposition to the program. 51a/ In addition, although there is no data on repair costs by income, it is thought that the vehicle owners asked to pay these highest costs are those least able to pay. Several programs (Arizona and California) have responded to these difficulties by instituting waivers for repairs in excess of a certain fixed amount (presently $150 in both States) or in excess of a certain percentage of the vehicle's value. Recent data suggest that repair cost ceilings as low as $75 - 100 incur little or no effectiveness penalty. 51b/

48/ Ref. 17, p. 2-29.

49/ Ibid.

50a/ Ref. 10.

50b/Ref. 20a.

51a/ 25,536 vehicles in New Jersey; 4,060 vehicles in Portland, and 7,755 vehicles in Arizona.

51b/Ref. 20a.

However, leaving these high costs aside there is some indication that the average repair cost range presently experienced in I/M programs may not be seen as excessive by most vehicle owners: the present average I/M-associated repair cost range ($16 - 32) is well below the average cost generally experienced for a tune-up ($40). 52/ However, should the preliminary California data on repair costs for catalyst-equipped vehicles prove correct, the average I/M repair cost will go up over time as the fleet composition changes. This will push repair costs closer to "regular" tune-up costs and, presumably, closer to the edge of public acceptability.

Cost Perception

Even assuming that I/M "repair" costs remain generally below normal maintenance costs, whether the public regards the price of I/M mandated "repairs" in the same way it views the price of a self-initiated tune-up geared to improve vehicle performance is debatable. Given the same price for a tune-up and an I/M repair, one would hypothesize that public acceptability would be higher for the tune-up than for the I/M repair. Unfortunately, there is no information available on this point. The above-mentioned difference in cost perception would be a reflection of the non-price characteristics of inspection/maintenance. I/M requires the vehicle-owning public to do business with the "universally distrusted" 53/ repair industry on a matter at present little understood by either party: maintenance for emissions control. I/M requires vehicle owners to have their vehicles tuned-up and requires that they do this within a certain amount of time. The benefits accruing to the vehicle owner for the money, time and effort involved are intangible (cleaner air) or imperceptible (improved mileage). 54/

52/ Ref. 3. NOTE: For the market acceptability analysis, the repair cost attributed to I/M is assumed to be the full repair bill, rather than approximately half the bill as discussed in the costs section of this report. Vehicles fail the inspection. Owners then must have them repaired. It is assumed that this sequence of events leads vehicle owners to perceive the inspection as the cause of the repair even though the information available on tune-up frequencies indicates that some of the work would have been done anyway, without the prod of I/M.

53/ Ref. 17, p. 133.

54/ "Even though the motoring public is generally aware that a well-tuned vehicle saves gas, the fuel economy benefits of I/M are not readily apparent to the consumer. Firstly, this is because the vehicle owner sees the inspection fee and repair bill taken from his pocket in one lump, whereas the monetary benefits of improved fuel economy are repaid to the consumer over a long period at an almost imperceptible rate. Secondly, there still abounds a widespread misconception that improvements in vehicle emissions are detrimental to fuel economy. Both these problems, however, are somewhat amenable through efforts to foster public awareness". Ref. 15.

Public Relations

The potentially negative effects of these non-price aspects of I/M may be counteracted in several ways. The to-be-tested public can be provided with information about the nature of the test and the capacity and performance record of the service industry. Most existing programs provide, at least initially, the first type of information, thereby sharpening the public's perception of I/M's benefits and softening the potentially abrasive impact of the program's mandatory nature. Information about the service industry's capability and performance serves to alleviate the public's general mistrust. Information about the industry's capabiltiy to perform emissions-related repairs is provided in New Jersey and California.

New Jersey provides vehicle owners with a list of service stations that have State-approved, emissions diagnostic equipment. These stations display signs, provided by the State, indicating that they have this emissions diagnostic capability. In California information is provided on both the service industry's capability and its performance. Mechanics performing emissions-related repairs must be certified by the State. They must perform the repair according to the State-specified procedures. In addition to these capability assurances, the California Vehicle Inspection Program Office is required by State law to publish a quarterly summary of facilities where repairs have been performed. This summary includes information on the location of the repair facility and the average cost of the repairs it has performed, as well as the refailure rate for the vehicles it has repaired. To date, the public's reaction to the California program has been relatively positive. 55/

Refailure Rates

All the above costs to the owners of flunked vehicles can be further aggravated if the vehicle flunks a second time. Data available on refailure rates for New Jersey and Oregon indicate that a refailure rate of 18 - 20% is reasonable to expect. 56 This reflects errors of either home

---

55 The program does not require repairs until September 1976. Whether the positive public reaction is due to this circumstance or to California's excellent public relations effort is difficult to determine. However, the public response to the institution of a similarly non-mandatory program in Arizona, which lacks such service industry information, has been quite negative. One may surmise that at least a portion of California's positive public response is a result of its public information work.

56 Refailure Rates:
Portland, Oregon - 16%
New Jersey - Phase I - 19.63%
Phase II - approximately 25% (NOTE: This figure is an estimate; reinspection in Phase II is done in private garages; however, 50% of those whose vehicles fail return to State lanes for a second reinspection, presumably to verify the results of the private garages; of this group, 25% fail a second time.) Ref. 8, 32, 39.

mechanics or the service industry. Insofar as refailure rates represent service industry failure, it is thought that they may be reduced via mechanic training and improved diagnostic information. In addition, over time, as mechanics acquire more experience with emissions repairs, the refailure rates could be expected to decrease "naturally."

o Summary of Vehicle Owner Costs o

In general, the calculable costs - inspection fee, inspection time, and repair costs - experienced by vehicle owners in existing programs seem to be, on average, within an acceptable range. However, with the exception of the inspection fee which is fixed, there is a risk associated with the other two cost categories of paying much more than the average, although the probability of paying more in repair bills and wait times is much smaller than the probability of paying less.

Uncertainties

The most startling fact about vehicle owner marketability is that the above statements are really all that can be said with any degree of certainty about this area. Indeed, even the information on consumer response to fees, wait times and repairs is tenuous. More information in these areas is sorely needed. More information is also necessary on the effects of test mode and mechanic training on repairs, particularly since the total repair bill represents a large component of total on-going expenditures (see Table 13). Since some of this information already exists for two idle mode programs (Portland and New Jersey), an ideal opportunity for collecting the data needed for comparison will be provided in the next 2 years by the Arizona (loaded mode, little mechanic training), and California (loaded mode, mechanic certification training) programs.

The relative absence of information on I/M's market acceptability and on the program variables that effect this vehicle-owner acceptability means that the first task of any future program is to collect information on what the public is willing to pay - in inspection fees, time and repair bills - for I/M. Given these limits, the second task is to tinker with the program variables that affect these costs - organizational structure, test mode and type, mechanic training and public information - to create a program that is within these publically acceptable cost boundaries. Once it has been ascertained that an inspection/maintenance program can be devised that is within the realm of public acceptability, the next question is whether or not the legal and institutional framework to implement such a program is available or likely to become available. The next section addresses itself to this question.

c. Legal and Institutional Framework

The ultimate likelihood of I/M implementation depends not only on its acceptability to vehicle owners, but also on the extent to which all levels of government have the authority necessary to operate and enforce the program. The inspection/maintenance authority of the Federal government, in the form of EPA, is presently in question. At the State level, I/M authority is sometimes present, more often not. Institutional factors which seem to effect the likelihood of securing authorizing legislation in the States where such legislation is absent are the existence of a vehicle safety inspection program in the area and the organizational structure of this already existing program.

o Federal Authority o

Since all existing emissions inspection programs have been created as a result of the transportation control planning process, the most important questionmark affecting the implementation of inspection/maintenance on a nationwide basis is EPA's authority to require the implementation and enforcement of I/M by the States. Recent court decisions have raised two kinds of issues respecting this authority:

1. does the Clean Air Act clearly provide EPA with the authority to require States to implement and enforce a promulgated measure?
2. if the CAA does indeed clearly grant EPA this authority, is this power constitutional?

Different circuits have handed down different opinions on these issues. While rulings in the Third and First Circuits have been favorable to EPA. those in the Ninth and Fourth Circuits have been unfavorable. (See Appendix C for case histories and decision summaries.) The most recent ruling, from the District Circuit, walks a middle line.

In *Pennsylvania v. EPA* (6/74), the Third Circuit held that the CAA and its *legislative history* clearly indicate that Congress intended EPA to be able to require States to enforce TCP regulations. It further held that such power is constitutional, "a valid exercise of the federal commerce power." In *South Terminal Corporation v. EPA* (9/74), the First Circuit *affirmed EPA's authority to enforce implementation* of TCP measures, provided that sufficient information exists to demonstrate the need for these measures. Unlike the Third Circuit case, *South Terminal* did not mention I/M specifically.

In contrast to these earliler rulings the decision of the Ninth Circuit in *Brown v. California* (8/75) held that EPA could not bring enforcement *actions against States* that failed to implement and enforce an EPA promulgated plan because the Clean Air Act did not clearly authorize such power. A decision in the Fourth Circuit, *Maryland v. EPA*, (9/75) also held that the Clean Air Act was not *sufficiently clear to permit* EPA to require States to implement and enforce an EPA promulgated regulation. Both decisions in the Fourth and Ninth Circuits noted that even if the Clean

Air Act had been clear in legislating such EPA authority, the court would regard this power with "constitutional reservations." such power.

Like the First and Third Circuits, the District Circuit Court tackled the issue of CAA clarity directly, finding the Clean Air Act sufficiently clear in its designation of authority to enable EPA to require a State to implement EPA promulgated regulations. However, the court found this authority unconstitutional respecting EPA's powers to require a State to pass authorizing legislation and actually operate an I/M program, but constitutional respecting EPA's powers to require States to refuse to register non-complying vehicles.

Given these five conflicting decisions, EPA has filed a brief with the Justice Department for submittal to the Supreme Court. The Court granted certiorari on June 7, 1976. Until the Supreme Court hears and decides the case, EPA's authority to enforce implementation of inspection/maintenance is considerably muddied.

o State Authority o

The authorities necessary to fully implement a viable I/M program at the State level are:

1. the authority to require that vehicles be inspected.
2. the authority to impose some sort of penalty on non-complying vehicles (e.g., to refuse to register such vehicles), and
3. the authority to require that vehicle owners pay a fee for the inspection.

Of the seventeen States and the District of Columbia that include I/M in their SIP, only six have authority to fully implement a mandatory inspection/maintenance program. Two States have limited I/M implementation authority and two cities have full I/M authority, although their States do not (see Table 14). Of the twelve States where I/M is required but not yet implemented, only two (New York and Pennsylvania) presently have on their books sufficient legislation to enable full I/M implementation.

91

TABLE 14

STATUS OF PERIODIC MOTOR VEHICLE INSPECTION

IN STATES WITH SIP'S REQUIRING I/M

	State	Area	PMVI (Safety)	Emissions Authority
1.	Alaska	Fairbanks	No	No.
2.	Arizona	*Phoenix *Tucson	No	Yes
3.	California	*Los Angeles Sacramento San Diego San Francisco San Joaquin Valley	No	Yes
4.	Colorado	Denver	PG	No [a,b]
5.	Illinois	*Chicago	CR	Yes[illegible]
6.	Indiana	Indianapolis	PG	No
7.	Maryland	D. C. Suburbs	No	No
8.	Massachusetts	Boston Springfield	PG	No [a]
9.	New Jersey*	N. Y. Suburbs Trenton	SR	Yes
10.	New York	New York City	PG	Yes
11.	Ohio	*Cincinnati	CR	Yes[c]
12.	Oregon	*Portland	No	Yes
13.	Pennsylvania	Philadelphia Pittsburgh	PG	Yes
14.	Texas	Dallas-Ft. Worth Houston San Antonio	PG	No
15.	Utah	Salt Lake City	PG	Yes[e]
16.	Virginia	D. C. Suburbs	No	No[d]
17.	Washington	Seattle Spokane	No	No
18.	District of Columbia		CR	No [a,b]

PG = Private Garage
CR = City Run
SR = State Run

* Existing emissions inspection program

a. Presently under consideration
b. Voluntary program in operation
c. Only local authority
d. Voluntary only for some counties in Northern Virginia
e. Authority to run program, but no authority to charge fee.

Ref. OTLUP, MSED, U. S. Environmental Protection Agency,
January, 1976

C7

Implementation Delays

Although this legislative fact tells little about the long term likelihood of I/M implementation, it does have something to say about this likelihood in the short term. Looking at the legislative history of existing programs (Table 15), the interval that reasonably can be expected to occur between the passage of enabling legislation by the State and the beginning of a fully mandatory, fully operational inspection/maintenance program is four years. 57/ Thus, in the 10 States with no/insufficient enabling legislation, no I/M program can be expected to be "in place" until 1980. Insofar as this lead time changes estimates of the program's effectiveness, it may also change State and local legislators' support for the program.

The reasons for the present implementation pattern remain unclear. However, there does seem to be some relation between the implementation of I/M for emissions and the existence of safety inspection programs.

o Existing Safety Inspection Systems o

The institutional factor that seems to have had most effect on the likelihood of I/M implementation at the State/local level is the existence of some form of periodic motor vehicle inspection in the emissions inspection area. Of the eighteen locations where I/M is required, twelve already have a PMVI for safety. Of these twelve programs, eight have a private garage organizational structure and four have centralized systems.

To date, it seems that emissions inspection has been easiest to implement in locations where there is a Government-run safety

---

57/ We are specifically talking about a State-run program. Although city-run programs have been able to start up within a year or two, it is also the city-run programs that have experienced the most severe enforcement problems. There are several reasons for this. In general, authority over vehicle registrations, the principal and strongest tool for enforcing I/M, rests with State, not local, governments. Secondly, city boundaries are often not commensurate with the mandated I/M program area. Where I/M authority rests with the city alone, enforcement of vehicles registered outside of city boundaries can be effective only with close interjurisdictional cooperation which is generally not easily achieved.

GL

TABLE 15

LEGISLATIVE HISTORY

Location	Enabling Legislation	Appropriation	Voluntary/Pilot Inspection	Mandatory I/M
Chicago, Ill.	11/71	*	6/73 (voluntary)	
New Jersey	1966	1968	7/72	1/74 - Phase I 11/75 - Phase II
Cincinnati, Ohio	(11/73 - EPA promulgates) 4/74	*	No voluntary/ pilot phase	1/75
Portland, Oregon	1971	8/73	1/74	6/75
Riverside, California	10/73	*	9/75	9/76 - For vehicl requiring registration changes 9/77 - For all LDV's in the S. Coast Air Basin
Maricopa and Pima Counties Arizona	5/70, 5/72	8/74	1/75	1/76

* Appropriation included in original authorizing legislation

inspection or where there is no program. Of the six existing emissions programs, three have been implemented in areas where there is a government-run system, and three in areas where there is no PMVI. No emissions inspection has as yet been implemented in the eight States where a private garage safety inspection already exists. Attempts to begin an emissions I/M have been made in three of these States, New York, Massachusetts and Pennsylvania, but have met with political opposition that has been successful so far in blocking the program's implementation.

Summary

Since the vehicle-owning public is effectively required to pay all the costs associated with an inspection/maintenance program (start-up costs and recurring costs via the inspection fee and the costs for repair) its acceptance of I/M is one of the most critical determinants of whether or not inspection/maintenance becomes a reality. While rough estimates of the costs themselves are available, relatively little is known about vehicle owners' perception of these costs.

The extremely limited data available suggests that the costs imposed on vehicle owners by existing I/M programs generally are not perceived as excessive. This is, however, the most tenuous of conclusions. In addition to data on cost and cost perception, information is needed on the market acceptability of the non-price aspects of I/M: its mandatory nature, the involvement it requires between vehicle owners and the automotive service industry, and the intangible character of its benefits. Much more information needs to be gathered on all the above issues before the market acceptability of inspection/maintenance can be understood. The rationale for securing such market information is that it would provide the cost and program characteristic boundaries for I/M within which a politically feasible program could be constructed.

The other critical factor affecting the political feasibility of I/M is the availability of adequate implementing authority. Authority at the Federal level is presently contested, and, until the Supreme court hands down its decision, confused. Authority exists in a third of the States where I/M is part of the SIP. Of the remaining twelve implementation areas, eight have an existing PMVI with a private garage organizational structure. The existence of this type of safety inspection system has in the past been related to difficulties in securing the passage of I/M enabling legislation. The prospects for I/M implementation in these areas over the short-term, before 1980, are not encouraging.

BIBLIOGRAPHY TO PART B: COST AND FEASIBILITY

Documents

1. Arizona Vehicle Emissions Inspection News, Hamilton Test Systems, HTS 09245-1, 2, 3, 6.

2. Auto Emissions Inspection Maintenance Training Program, OAWM, MSED, OAF, Environmental Protection Agency, March, 1976.

3. The Automobile Tune-Up, Champion Spark Plug Company, 1975.

4. "Benefits of a Vehicle Inspection Program...", Automotive Fleet, July 1975.

5. Costs and Benefits of Motor Vehicle Inspection, Office of State Vehicle Programs, NHTSA, U. S. Department of Transportation, January 1975.

6. Cutro, Joseph, I/M Fact Sheets, OTLUP, U. S. Environmental Protection Agency, November 1975.

7. Demkovich, Linda E. and Pierce, Neal R., "Urban Report/New York's Fiscal Woes May Be Catching, Study Warns," National Journal, 11/8/75, pp. 1540 - 40.

8. Elston, John and Cowperthwait, Daniel, New Jersey's Auto Emissions Inspection Program: An Assessment of One Year's Mandatory Operation, New Jersey Department of Enviornmental Protection, 1975.

9. "Fleet Emission Inspections Save Fuel, Money for City of Phoenix," Arizona Roadrunner, May 1975.

10. The Fourth North American Motor Vehicle Emission Control Conference, Anaheim, California, November, 1975.

11. Grad, Frank R., Rosenthal, Albert J., Rockett, Laurie R., Fay, James A., Heywood, John, Kain, John F., Ingram, Gregory K., Harrison, David, Jr., Tietenberg, Thomas. The Automobile and the Regulation of its Impact on the Environment, University of Oklahoma Press, 1975.

12. Inspection/Maintenance of Light Duty Vehicles in the Denver Air Quality Control Region, report prepared for Colorado Department of Health and EPA Region VIII by TRW, November 1974 (executive summary and technical report).

13. Inspection/Maintenance Programs for Fuel Economy Improvement, Draft of FEA document, November 1975.

14. *Mobile Source Control: Summary Remarks*, Session III, Moodus Conference, September 1975.

15. "Perceived Costs of Inspection Maintenance: The Consumer's Point of View", *Inspection Maintenance - Binder of Background Material*, EPA, April 1976.

16. *A Program Plan for Implementation of Vehicle Inspection/Maintenance in Four Regions of Texas*, Draft of a final report prepared for EPA, Region VI by Radian Corporation, June, 1975.

17. *Report by the Committee on Motor Vehicle Emission*, National Academy of Sciences, November, 1974.

18. *A Review of Control Strategies for In-Use Vehicles*, by the Environmental Programs Group, the Aerospace Corporation and the Emission Control Technology Division, U.S. EPA, December, 1974.

19. *South Coast Air Basin Vehicle Emission Inspection Program Design Study*, Final Report prepared for California Department of Consumer Affairs, Bureau of Automotive Repair by Olson Laboratories, Vols. I, II, May, 1975.

20a. *Statement of Appropriations and Expenditures*, Department of Law and Public Safety, Division of Motor Vehicles, State of New Jersey, August, 1975.

20b. State of California, Air Resources Board, *Evaluation of Mandatory Vehicle Inspection and Maintenance Programs: Summary Report*, May, 1976.

21. State of New Jersey, Division of Systems and Communications, *Vehicle Pollution Failure Tabulation*, November 11, 1972.

22. *A Study of Emission Control Device Tampering in New Jersey Motor Vehicle Population*, Final Report conducted by the New Jersey Division of Motor Vehicles and the Department of Environmental Protection, November, 1974.

23. *Task Force Report: Vehicle Inspection/Repair Systems*, New York Department of Motor Vehicles, Vol. 1, 1974.

25. Zerbe, Richard O. and Croke, Kevin. *Urban Transportation for the Environment*, Ballinger, Cambridge, Mass., 1975.

CONVERSATIONS AND CORRESPONDENCE

25. John Hesse,
Department of Public Relations
Hamilton Test Systems, Arizona; telephone conversations February, March and June, 1976. ((602) 955-9670)

26a. Frederick Iacobelli, Chief
Bureau of Vehicle Emissions Inspection. Arizona Department of Health Services; telephone conversations February and March, 1976. ((602) 271-4548)

26b. __________, correspondence, June, 1976.

27. John H. Dolan, Assistant Chief, Vehicle Inspection Programs and Motor Vehicle Pollution Control Operations, Bureau of Automobile Repair, California Department of Consumer Affairs, telephone conversation, March, 1976 ((916) 322-2823)

28. __________, correspondence, March, 1976.

29. Bruce Carhart, Progam Specialist- Transportation Related Pollutants, Air Planning Section, Air Policy Branch, EPA, Region V, Chicago, Illionois; telephone conversations, February, March, April, and June, 1976. ((212) 566-0990).

30. __________, correspondence, March 1976.

31a. T. T. Kason, Deputy Commissioner
Department of Environmental Control, City of Chicago, Illinois; telephone conversation, April 1976. ((312) 744-4067).

31b. __________, correspondence, May 1976.

32. John Elston, Principal Environmental Engineer
Bureau of Air Pollution Control, New Jersey Department of Environmental Protection; telephone conversations February and March, 1976. ((609) 292-6714).

33. __________, correspondence, February and May, 1976.

34a. Robert McMinn, Deputy Director
Division of Motor Vehicles, State of New Jersey telephone conversations February, March and June, 1976. ((609) 292-4593).

34b. __________, correspondence, June, 1976.

35. Fidelis D. Newcomb, Technical Assessment Bureau
Division of Vehicle Safety, New York Department of Motor Vehicles, telephone conversation, January, 1976. ((518) 474-5497).

36. __________, correspondence, January, 1976.

37a. Marion Smith, Senior Engineer
Division of Air Polluton Control, Department of Sewers, City of Cincinnati; telephone conversations, March, 1976 . ((513) 342-4880).

37b.__________, correspondence, May, 1976.

38. Thomas J. Frey, Superintendant of the Municipal Garage Department of Public Utilities. City of Cincinnati; telephone conversations, March, 1976. ((513) 352-3711).

39. Ronald Householder, Administrator
Vehicle Inspection Program
Oregon Department of Enironmental Quality; telephone conversations February, March and June, 1976. ((503) 229-6200).

40. ______________________, correspondence, March, 1976.

41. James Forrester, Theodore Baylor, National Highway and Traffic Safety Administration, U. S. DOT, interview, January, 1976.

PART A: EFFECTIVENESS

14.

APPENDIX A: EXISTING STATE INSPECTION/MAINTENANCE PROGRAMS

MARICOPA and PIMA COUNTIES, ARIZONA

A. Institutional and Legal Framework

1. Organizational Structure:
   centralized - State contracts with Hamilton Test Systems.

2. Agencies Involved:
   - a. Arizona Department of Health Services, Bureau of Vehicular Emissions Inspection - monitors and reimburses contractor, inspects fleet testing stations.
   - b. Department of Motor Vehicles - refuses to register non-complying vehicles.
   - c. Hamilton Test Systems - operates program, submits reports to State; bills State bi-weekly; is reimbursed $4.45 for each "billable" inspection; 5-year contract.

3. Implementation Area: Counties with population greater than 350,000, e.g., Maricopa and Pima Counties, which include the greater metropolitan areas of Phoenix and Tucson.

4. Legislative History:
   - a. April, 1969 - Health Department's authority expanded to include motor vehicles and ICE emissions.
   - b. May 22, 1972 - Chap. 14, Art. 2, 36-1751-54 establishes authority for Motor Vehicle Emissions Pilot Program.
   - c. May, 1974 Director of Health Services ordered to establish program by January 1, 1976.
   - d. August, 1974 - first appropriation, $132,000.
   - e. November, 1974 - HTS awarded contract.
   - f. May, 1975 - mandatory maintenance delayed until January, 1977.
   - g. January 1, 1976 - program begins with voluntary maintenance.

5. Frequency of Testing: annually, with registration cycle.

6. LDV's Affected: 1.1 million.

B. Technical Characteristics

1. Test Type: Emissions only.
2. Test Mode: Loaded
3. Flunk Rate: Projected 35%; actual 50% first 16 weeks.

C. Program Costs - 37 Lanes

1. Start-up: $9,000,000
   - a. Building: $3,600,000
   - b. Land: $1,400,000

37 lanes - 1 mobile van
12 permanent centers.

- c. Equipment: $3,000,000 (Note: includes installation and engineering)
- d. Administration: $1,132,000
  - $132,000 for State,
  - $1,000,000 for HTS in general administration, installation, early hiring (by 2 months) and training of inspectors.

2. Recurring Costs: $4,480,000
   - a. Administration: $680,000*
     - $330,000 for State,
     - $350,000 for HTS.
   - b. Inspection: $3,700,000.*
   - c. Public Relations: $250,000 in first year

D. Political Feasibility

1. Consumer Costs
   - a. Wait Times: 15 - 45 minutes
     planned for average 10 minute wait, but monthly fluctuations - beginning of month = no wait, end = up to 1 hour.
   - b. Inspection Fee: $5 for initial inspection; second inspection free with completed "failure and repair form;" after that, pay again.
   - c. Maintenance:
     - 24% = less than $5
     - 20% = $5 - $10
     - 29% = $10 - $25
     - 18% = $25 - $50
     - 7.5% = $50 - $100
     - 1.5% = over $100.

     (Note: Data from an original sample of 1,000. Half of these data points were thrown out in computing the presented maintenance costs because the vehicle owners had performed their own repair work).
   - d. Refailure Rate: 54% for the 6% of failed vehicles returning.
   - e. Test Time: 5 minutes

2. Consumer Information Protection
   - a. Mechanic Training: Planned with $5,000 from EPA through HEW
   - b. Diagnostic Information: Fail card includes standards, probable cause of failure.

*Includes fringe.
Ref. 1, 2, 4, 6, 9, 10, 25, 26a, 26b.

CINCINNATI and NORWOOD, OHIO

A. Institutional and Legal Framework

1. Organizational Structure: Centralized - city-owned and operated

2. Agencies Involved:
    a. Division of Air Pollution Control, Cincinnati Department of Sewers - planning, air monitoring and lab work, some enforcement via the "Green Hornets."
    b. Municipal Garage, Department of Public Utilities - operates program.
    c. Cincinnati Police Department - enforce sticker system (NOTE: Virtually no cooperation on enforcement via registration from State of Ohio.)

3. Implementation Area: Hamilton County, including the City of Cincinnati and Norwood.
    a. Interjurisdictional difficulties: Cincinnati requires that vehicles "commonly on the streets" in Cincinnati must have a Cincinnati sticker (representing a safety and emissions inspection); vehicles with only Hamilton County stickers (representing an emissions only inspection) were considered in non-compliance due to lack of safety test.
    b. Program in Hamilton County closed February 1, 1976, due in part to the difficulties described above, but also due to the fact that in Ohio the county is a relatively weak form of government; e.g., in Hamilton County the sheriff's office was the enforcement arm of the program, although technically the sheriff could only enforce the county law on county roads. Problems such as these are exacerbated by the State's lack of cooperation.

4. Legislative History:
    a. Ohio submits SIP; overestimates emissions reduction for some measures; EPA adds I/M and promulgates on November 9, 1973.
    b. City of Cincinnati passes I/M ordinance: April 1, 1974.
    c. Fully mandatory I/M program begins: January 2, 1975. NOTE: A city-run safety inspection has been in operation in Cincinnati since 1940.
    d. Notices of violation and enforcement orders have recently been issued to Hamilton County and the State of Ohio. The county is required to enforce I/M by September, 1976 for all vehicles within the county but outside of Cincinnati's jurisdiction and to reopen their two stations should Cincinnati and Norwood need additional inspection lane capacity. The State of Ohio is set on a compliance schedule which requires the State to refuse to register all non-complying Hamilton County vehicles beginning no later than July 1, 1977.

5. Frequency of Testing: Since January 1, 1975, annually.

6. LDV's Affected: 510,000 vehicles registered in Hamilton County, of which 250,000 are in Cincinnati (including Norwood.
   Actual throughput for 1975:
   Cincinnati = 114,048
   Norwood = 69,802.

   NOTE: Low throughput rate is attributed to lax enforcement by the local police due to confusion surrounding sticker requirements. The confusion is due to the change from a semi-annual to an annual inspection which was effective January 1, 1975. Since January 1, 1976, there has been a significant increase in citations for sticker violations.

B. Technical Characteristics

1. Test Type: Emissions and Safety.

2. Test Mode: Idle.

3. Flunk Rate: Emissions only: 31.89% (Norwood), 21.5% (Cincinnati)
   NOTE: Previously safety-only flunk rate had been approximately 18%.

	HC Only	CO Only	Both
Cincinnati:	2.6%*	15.9%	3.0% **
Norwood:	3.1%	24.9%	3.8%

*Figures represent % of all vehicles. **Includes 25% fringe.

C. Program Costs - Four Lanes

1. Start-up:

a.	Building	No new costs incurred because emissions inspection
b.	Land	was added on to an existing safety inspection.

NOTE: Replacement value for buildings and equipment (including emissions) = $600,000.

NOTE: Land valued roughly at $40,000/A
Cincinnati Station 5 - 10A = $200,000 - 400,000
Norwood Station 1A = $40,000.

c. Equipment: $12,070 for 9 analyzers
   $1,290 for 7 Cincinnati analyzers.
   $1,520 for 2 Norwood analyzers.

NOTE: The prices quoted are special contract prices for 1974. The May 1976 replacement prices are $2,195 (less 20% Government discount) for the unit without an RPM counter or $2,960 for the unit with an RPM counter.

2. Recurring: Total $535,000 for 1975 (not including enforcement).
    a. Administration: approximately $165,000* for 9 staff.
    NOTE: No additional cost for emissions, done by Public Utilities employees.
    b. Inspection: approximately $220,000* for 22 staff.
    (Note: 11 new positions were originally added to the inspection staff when emissions inspection was initiated; however, the low throughput rates experienced in 1975 resulted in 18 inspection staff being laid-off, including the 11 new inspectors; a recent increase in throughput has resulted in the rehiring of 11 of the 18 inspectors laid-off.
    c. "Non-Personnel" $50,000
    d. "Special": $100,000 (includes printing, repairs on equipment, maintenance of photographic equipment to take pictures of "unroadworthy" vehicles, etc.)
    e. Enforcement: $134,000 - 179,000 total.
    $44,000 - half of "Green Hornets" (local air pollution enforcement vehicles) annual budget.
    $90,000 - 135,000 - local police force cost attributed to emissions enforcement. The first figure does not include costs for administrative support to officers who issue citations. Both figures represent 60% of the total costs of enforcing inspection violations since approximately 60% of all LDV's failed fail for emissions.

D. Political Feasibility

1. Consumer Costs:
    a. Wait times: 0 - 30 minutes
    Estimated average for normal operation = 15 - 20 minutes.
    b. Inspection Fee: $3.75 NOTE: formally $3.50 under the safety only inspection
    c. Maintenance: this information is not collected.
    d. Refailure Rate: No records are kept on refailure rate. Most failed cars are passed on the next inspection, which must occur within 30 days of the failure. A few cars require a third test.
    e. Test time: 30 seconds for emissions; maximum 5-10 minutes for full emissions and safety

*Includes 25% fringe. Ref. 6, 29, 30, 37a, 37b, 38

2. Consumer Protection and Information:
    a. Mechanic Training: week long course in June, 1976 for vocational education instructors begins tie-in with Ohio vocational education system.
    b. Diagnostic Information: general "reasons for failure" on fail card.

3. Financing (FY/75):
    a. City - inspection program part of current budget
    b. State - no funds
    c. Federal - EPA: $40,000 used for analyzers and training ($32,000 to Hamilton County; $8,000 to Norwood)

PORTLAND, OREGON

A. Institutional and Legal Framework

1. Organizational Structure: Centralized - State-owned and operated.

2. Agencies Involved:
    - a. State DEQ - operates program.
    - b. Motor Vehicle Division - refuses to register vehicles without DEQ certificate.

3. Implementation Area: Metropolitan Service District
    - a. Service district used as it is generally more densely populated than the three counties that constitute the Portland SMSA.
    - b. Using service district boundaries resulted in some difficulties in determining exactly which vehicles were required to be inspected. Vehicle registrations are all done on a county basis and service district boundaries are not commensurate with county boundaries. In addition, people are generally unaware of their residences' location relative to sewer districts. These initial difficulties have been overcome with public relations work, e.g., enclosing maps of the sewer district with re-registration materials sent to all potentially effected vehicle owners.

4. Legislative History:
    - a. Initial legislation passed in 1971.
    - b. $1 million appropriated for pilot program to do voluntary testing on 100,000 LDV's: August, 1973.
    - c. Pilot program begins: January, 1974.
    - d. Regulations promulgated: March 28, 1975.
    - e. Mandatory I/M begins: June, 1975.

5. Frequency of Testing: upon re-registration which occurs every two years.

6. LDV's Affected: 580,000

B. Technical Characteristics

1. Test Type: Emissions only.

2. Test Mode: Idle (1 loaded mode station).

3. Flunk Rates: 35%; of these
    70% fail for CO only
    11% fail for HC only
    10% fail for HC and CO
    9% fail for "other."

C. Program Costs - 15 Lanes

1. Start-up
   a. Building $77,000 (1 inspection station)
   30,750 (6 vans - Purchase price: $18,750
   Outfitting cost: 12,000*).
   b. Land: Leased.
   NOTE: The one permanent station is on land owned by the State Highway Department. This land is leased by DEQ for $1/year and is valued at ($2.75/sq. ft. for 26,846 st. ft.) approximately $74,000.
   c. Equipment: $203,000 (29 analyzers at $7,000/analyzer-built to DEQ specifications)
   d. Administration: $800,000 NOTE: Includes 18-month operation of a pilot program.
   e. Financing: $15,750.

2. Recurring Costs
   a. Administration: $147,042/year**
   includes: 2 engineering positions
   3 field supervisors
   1 supervisor of all daily activities
   1 director
   2 secretaries
   b. Inspection: $820,984**/even years; $317,189**/odd years
   75 positions even years, 27 odd years
   NOTE: This fluctuating cycle due to bienniel registrations results in a higher fringe rate because of unemployment benefits.
   c. Leasing: $81,600/year
   4 lease sites at 1,700/month
   2,100/month
   2,600/month
   400/month

   NOTE: The vans (with one exception) incur no land leasing costs since they are constantly changing location - using school parking lots, shopping centers, abandoned service stations, used car lots, an abandoned grocery store lot. Although this approach saves land costs, care must be and is taken to respect local zoning ordinances.

---

*Does not include analyzers
**Includes 16.7% fringe

D. Political Feasibility

1. Consumer Costs
    - a. Wait times: average = 15 minutes; 1 hour = a reasonable maximum.
      NOTE: Longer times experienced initially for the first full registration cycle - the pilot project station was overloaded as vehicle owners tended to go to the familiar station.
    - b. Maintenance:
      27% = no charge
      37% = less than $10
      18% = $10 - 30
      8% = $31 - 50
      5% = $51 - 75
      3% = $75 - 100
      2% = over $100.
      NOTE: 72% of all repairs were for carburetor adjustments.
    - c. Inspection Fee: $5 (legislatively mandated maximum).
    - d. Refailure Rate: 16%.
    - e. Test Time: 5 minutes (nominal figure; optimal time = 3 minutes).

2. Consumer Information and Protection
    - a. No mechanic training as yet.
    - b. Diagnostic Information : "fail form" includes the applicable standards, the actual readings, and in a general way, the likely causes of failure; large booklet with considerable diagnostic detail available on request.

3. Financing
    - a. State : program funded as a line item on the Oregon State Budget
      NOTE: Semi-annual registration cycle has caused cash flow difficulties resulting in a need to borrow $225,000 from the State to be repaid at $25,000/mo. with 7% interest rate.
    - b. Federal: $25,000 for training inspectors (spring 1975)
      NOTE: The process for securing the Federal funds was more complicated than optimal.

Ref. 6,10, 39,40

IRI.

CHICAGO, ILLINOIS

A. Institutional and Legal Framework

1. Organizational Structure: Centralized - city-owned and operated.
2. Agencies Involved: Department of Environmental Control, City of Chicago.
3. Implementation Area: City of Chicago and Cook County
4. Legislative History:
   a. City adopts I/M ordinance, November 29, 1971.
   b. Testing begins, June, 1973.
   c. EPA promulgates SIP including I/M, December, 1973.
   d. Notification of violation of TCP to Chicago and Cook County, April, 1975.
   e. Following a statutory conference and negotiations, 113 letters were issued to Chicago and Cook County specifying the following:
      1. voluntary I/M could be continued as long as throughput rates were increased to 3,000 day by December, 1975, otherwise the inspection must become mandatory, by March, 1976 and
      2. Cook County is required to assure that LDV's registered in Cook County and "operated within the Chicago CBD" are inspected.
   f. Despite considerable public relations efforts by Chicago to increase throughput rates, at present the mandated rate has not yet been reached.
5. Frequency of Testing: Annually.
6. LDV's Affected: 1,000,000 (City of Chicago only).

B. Technical Characteristics

1. Test Type: Emissions only.
2. Test Mode: Idle. (low and high)
3. Flunk Rate: Approximately 30%.

C. Program Costs - 18 lanes

1. Start-up
   a. Land: No expenditure required as sites are abandoned city parking lots.
      NOTE: "Guesstimate" of land value - $1,000 - 1,200/front foot; 100 x 200 ft. = minimum site area. Land values range from $100,000 - 240,000/site for 9 sites; total land value $900,000 - $2,160,000.

- b. Buildings and Equipment: $1,710,000 total.
    Semi-open air structures = $ 40,000/structure
    $360,000 total.
    Electric service for structures = $100,000 for all structures
    12 mobile vans at $100,000/van = $1,250,000.
    NOTE: Vans equiped with analyzers, tape deck, computer terminal.
- c. Administration: $600,000 for preliminary consulting work - primarily design of physical system.

2. Recurring
    - a. Administration: $160,224* for 10 positions
    - b. Inspection: $819,264* for 75 positions, including 18 site supervisors
    - c. "Goods and services": $600,000.
        NOTE: Includes yearly preventative maintenance contract with Sun, equipment repalcement, etc.

NOTE: Originally budgeted for 105 staff at $1,400,000.*

D. Political Feasibility

1. Consumer Costs
    - a. Wait Time: 5 minutes.
    - b. Inspection Fee: Free (included in city vehicle tax which was increased by $5 at the time the I/M program began)
    - c. Maintenance: Data not available.
    - d. Refailure Rates: Data not available.
    - e. Test Time: 5 minutes maximum.

2. Consumer Protection and Information
    - a. Mechanic Training: No program as yet.
    - b. Diagnostic Information: General information on testing procedure.

3. Financing
    - a. City - Line item on City Budget.
    - b. State - None.
    - c. Federal - None.

---

* Includes 12% fringe.

Ref. 6, 10, 29, 30, 31a, 31b.

NEW JERSEY

A. Institutional and Legal Framework

1. Organizational structure: centralized - State-owned and operated.

2. Agencies involved:
   a. Division of Motor Vehicles, Department of Law and Safety - operates program; enforces via registrations.
   b. Bureau of Air Pollution Control, Department of Environmental Protection - sets standards, provides technical support; maintains emissions equipment.

3. Implementation area: all of State of New Jersey.

4. Legislative history:
   a. State Clean Air Act (includes I/M) - 1966.
   b. Demonstration project (HEW and New Jersey funds) - 1968, 69.
   c. Regulations promulgated - January, 1972.
   d. Advisory testing begins - July, 1972.
   e. Mandatory maintenance with Phase I standards begins February, 1974.
   f. Phase II standards in use at all stations, November, 1975.

5. Frequency of testing: annually, with registration.

6. LDV's affected: 3,800,000

NOTE: Total inspections performed in 1975 were 5,523,671. This includes reinspection of vehicles failing the first test, inspection of all used cars that changed ownership during the year and all motorcycles.

B. Technical Characteristics

1. Test type: emissions and safety.

2. Test mode: idle.

3. Rejection rate: Phase I: 12% for emisisons (6% emissions only)
   47% total for emissions and safety

   of the 12% failing for emissions, causes for failure wer
   50% - CO
   30% - HC
   8% - HC and CO
   15% - excessive smoke

   Phase II: 18% for emissions (11% for emisions only)
   50% total for emissions and safety

   NOTE: 1972 (safety only) - 43.2 % flunk rate: in 1975 DMV relaxed safety criteria to keep down the total number of vehicles flunked.

C. Program Costs - 68 lanes

1. Start-up
   - a. Land
   - b. Buildings

   No additional expense incurred due to emissions, since facilities were already present for safety inspections (which had begun in 1938).

   NOTE: Replacement costs for land and buildings of 24 stations with 51 lanes owned by the State estimated at:
   - a. Land - 5A/2 lanes at $40,000/A = $4,800,000
   - b. Buildings - $500,000 to construct each lane = $25,00,000.

   NOTE: Variability in these costs is considerable: a single lane station in South Jersey cost $160,000 for construction and zero for land (donated by municipality); a 3-lane station in Newark cost $1,500,000 for construction and $400,000 for 3A of land.

   - c. Equipment: $250,000 total
     $1,600/analyzer for 125 analyzers, plus
     50,000 for related expenses (sockets, utility closets, etc.).

   - d. Administration: $2,400,000 (the DEP program budget from 1967 - 72)

1967	- approx. $ 30,000	(2 salaries)
1968-69	1,250,000	(HEW demo)
1970	320,000	(mobile lab and salaries)
1971	250,000	(salaries)
1972	555,000	(salaries, equipment, installation, training).

   NOTE: DMV received no additional monies for start-up.

2. Recurring
   - a. Administration: $ 330,000 (DEP) + 82,500 (Treasurer-fringe)
     96,000 (DMV) + 24,000 (Treasurer-fringe)

   - b. Inspection: $ 7,491,176 (DMV) + 1,872,941 + 300,000 (see below)
     NOTE: A salary increase was granted inspectors due to the addition of emissions inspection to their tasks- the total amount of their increase = $464,195. (Includes 25% fringe.)

   - c. Leasing: approx. $200,000/yr. for 8 stations and 5 lots with 17 lanes. NOTE: Not included in DMV/DEP budget.
   - d. Overhead: $840,000

DMV -$1,872,941 = fringe on $7,491,176 of gross salary, $300,000 premium portio overtime

D. Political Feasibility

1. Consumer Costs
    a. Wait times:

1972 (before emissions)	5 min.
1972 (after emissions)	9 min.
1973 (+ insurance)	10.41 min.
1974	16 min.
1975	13 min.

    b. Inspection Fee: $1 - collected as part of registration fee; $1 at private garage reinspection. NOTE: This fee is the same as that charged in 1938 when safety inspections first began; legislature has just passed a bill that will raise the registration fee by $1.50, resulting in a total initial inspection fee of $2.50.

    c. Maintenance Costs: For emissions repairs, 1974
        29.7% - less than $10
        26.4% - $10 - 25
        22.1% - $25 - 50
        16.1% - $50 - 100
        5.6% - over $100.

    d. Refailure Rate: Phase I = 18% of the 12% failed
        Phase II = unclear due to private garage reinspection; however, 50% of those flunked return to State lanes and of this group, 25% fail again.

    e. Test Time: 6 min. (emissions and safety)
        30 sec. (emissions only)

2. Financing
    a. State - general revenues
        NOTE: $4,400,000 earmarked for inspection, remainder of budget must be secured annually from the Legislature. (New cars pay the $1.00 fee as part of registration, but are not inspected for 2 years. Trucks over 6,000 lbs. g/w also pay the fee to cover costs of random road inspection. Thus, $4,400,000 is collected, although only 3,800,000 vehicles are subject to inspection at inspection stations.)
    b. Federal - HEW - $1,000,000 in start-up monies (used primarily to contract out the development of emissions inspection standards and test procedures).

Ref. 6, 8, 20a, 22, 32, 33, 34a, 34b.

RIVERSIDE, CALIFORNIA

A. Institutional and Legal Framework

1. Organizational Structure: centralized - State-owned and operated. (NOTE: Legislation required this organizational structure for consumer protection reasons.)

2. Agencies Involved:
   a. Bureau of Automotive Repair, Department of Consumer Affairs - houses administrative staff and does payroll for all Vehicle Inspection Staff.
   b. California Air Resources Board - in legislation ARB's sole function was envisioned as standard-setting; in fact, ARB effectively administers and operates the program, e.g., contract to install equipment was an ARB contract; money for program operation is put into the ARB budget and then transferred to DCA. NOTE: Both ARB and BAR agree that the Vehicle Inspection Division should become a part of ARB; they are presently in the process of suggesting amendments to institute this change.
3. Implementation Area: City of Riverside (Phase I)
   South Coast Air Basin (Phases II and III)

4. Legislative History
   a. Legislation passed October, 1973, effective January, 1974.
   b. Regulations promulgated: September, 1974.
   c. Riverside stations open September, 1975.
   d. I/M mandatory for vehicles requiring registration changes: September, 1976.
   e. I/M mandatory for all LDV's in the South Coast Air Basin: late 1977.

5. Frequency: annually (Phase III) with registration

6. LDV's Affected: 142,000 (Phase I)
   1,600,000 (Phase II)
   8,000,000 (Phase III)

B. Technical Characteristics

1. Test Type: emissions only.

2. Test Mode: loaded, includes NOx.

3. Flunk Rate: projected 25%; actual 30%.

C. Program Costs

1. Start-up
   a. Building leased with option to buy in 2 years.
   b. Land

c. Equipment: $579,213
   NOTE: Equipment cost includes eight different tasks to be performed by the equipment contractor, only one of which is actually supplying the instrumentation.

   NOTE: Lower prices are expected for equipment in Phases II and III due to quantity procurement and competitive bidding procedures (present equipment purchased under a sole source contract to avoid delays; competitive capital outlay procedures take 2 - 3 years).
d. Administration: $400,000.
e. Financing: $320,000 (to date; represents 8% interest on roughly $4,000,000)
f. Public Relations: $50,000 (to date)

2. Recurring Costs
   a. Administration: $197,286* (11 positions)
   b. Inspection: $415,681* (30 positions)
   c. Leasing: $255,360/yr. (6 lanes, 2 facilities)
      NOTE: The owner of the land and buildings is under contract to the State for two years. Consequently, he's amortizing the entire cost of his building investment in two years. Should the State continue to lease those properties, the cost would drop considerably, to $85,020/yr.
   d. Equipment Replacement: roughly $100,000. (20% of equipment costs)

D. Political Feasibility

1. Consumer Costs
   a. Wait Times: Presently virtually none; plan an average wait of 8 - 10 minutes.
   b. Inspection Fee: $5 (projected - no fee is actually charged in Phase I).
   c. Maintenance: $21 - 23, on average.
   d. Refailure Rate: During first two months of operation = 21%.
   e. Test Time: 7 minutes.

2. Consumer Protection and Information
   a. Mechanic Training: There is special licensing in California for one category of mechanics, "installer adjusters" (those who install pollution control equipment); during Phase I, mechanics who want to do repairs for vehicles participating in the I/M program must obtain a Certificate of Qualification by attending an eight-hour workshop (lecture and hands-on) and either possess an installer adjuster's license or pass a written exam; in addition to this training, all mechanics repairing I/M vehicles are required to follow procedures specified by BAR.

---

* Include 16.5% fringe.

b. Diagnostic Information: Print-outs of standards and readings at all modes plus detailed "diagnostic messages."

c. Service Information: Law requires that BAR publish
   1. (Phase I) a list of certified mechanics and
   2. (Phases II and III) a quarterly summary of facilities where repairs have been done including the average cost of repairs at particular stations and the refailure rate of cars repaired at that station.

3. Financing
   a. Source: State Motor Vehicle Department
   b. Arrangement: Reimbursable loans - need to repay loan at going interest rate, amortize and replace all equipment within 5 years.
   c. Amounts: FY 73 - $400,000
      FY 74 - 75 - $2,600,000
      FY 76 - 77 - 18,800,000 (estimated)
      Total Expenditures to date: $3,500,000 - 4,000,000

Ref. 10, 19, 20b, 27 28.

APPENDIX B: I/M COST ESTIMATES

1121

TABLE 8

CAPITAL COST ESTIMATES FOR PUBLICLY OWNED AND OPERATED SYSTEMS

DATA SOURCE	# LANES	TEST MODE	ADMINISTRATION	EQUIPMENT	BUILDING/CONSTRUCTION	LAND	OTHER CONTINGENCIES	TOTAL
EPA, OTLUP MSED	2	IDLE	$5,000	9,400	60,000	14,000-140,000	4,900-7,000	$93,300-221,400
EPA, OTLUP MSED	2	LOADED	5,000	17,800	60,000	14,000-140,000	4,500-10,800	101,300-233,600
BATTELLE, TCP 5/75	2	IDLE	3,000	16,870	35,000	14,000-140,000	AUTOMATION: 14,850 CONTINGENCIES: 4,090-7,000	87,810-216,720
BATTELLE, TCP 5/75	2	LOADED	3,000	24,270	35,000	14,000-140,000	AUTOMATION: 14,850 CONTINGENCIES: 4,500-10,800	95,620-227,920
"CONTROL STRATEGIES FOR IN USE VEHICLES," '74	2	IDLE		26,720	87,500			114,220
"CONTROL STRATEGIES FOR IN USE VEHICLES," '74	2	LOADED		38,720[a]	90,500			129,220
OLSON, SCAB, VEI STUDY 5/75	2	LOADED	26,600[c]	99,500[a,b]	NEW: 144,800 REHAB: 12,000	94,500 132,000		365,400 270,100
NEW YORK, '74	2	LOADED		29,796	68,932	130,592		229,320
NEW YORK, '74[d]	2	LOADED		62,430	264,075	125,996		452,501
DENVER TRW, '74	2	IDLE	7,039	17,194	48,513	30,323		103,069
DENVER, TRW, '74	2	LOADED	7,000	33,529	48,294	29,971		118,794

a/ INCLUDES NO_X ANALYZERS
b/ AUTOMATED
c/ INCLUDES PERSONNEL TRAINING
d/ SAFETY AND EMISSIONS INSPECTION

CHART II

CAPITAL COST ESTIMATES FOR PRIVATE GARAGE SYSTEMS

DATA SOURCE	# OF LDV'S	ADMINISTRATION	EQUIPMENT	BUILDINGS AND LAND	TOTAL
EPA - OTLUP 1/76	1,000,000	$ 25,000	2,200,000[a]		$ 2,225,000
BATTELLE, TCP 5/75	2,000 (2 LANES)	3,000	17,870		20,870
TEXAS, RADIAN 6/75	3,400,000 (3,382 STATIONS)	391,000	6,764,000		7,155,000
DENVER, TRW, 1974	896,000 (600 STATIONS)	622,000	2,040,000		2,662,000

a/ AVERAGE # LDV'S INSPECTED/STATION/YR - 1,000 (ESTIMATE DERIVED FROM RADIAN AND DENVER STUDIES)
STATIONS NEEDED FOR 1 MILLION LDV'S - 1,000
EQUIPMENT COST/STATION - $2,200

NOTE: ALL STUDIES ASSUME AN IDLE MODE TEST

CHART III

RECURRING COST ESTIMATES FOR PUBLICLY OWNED AND OPERATED SYSTEMS

DATA SOURCE	# LANES	TEST MODE	ADMINISTRATION	INSPECTION	SUPPLIES	OTHER	TOTAL
EPA, OTLUP MSED	2	IDLE AND LOADED	$ 33,060	64,000	2,940		$100,000
BATTELLE, TCP 5/75	2	IDLE AND LOADED	33,060	64,000	2,940		100,000
"CONTROL STRATEGIES FOR IN-USE VEHICLES," 5/75	2	IDLE AND LOADED					100,000
OLSON, SCAB VEI STUDY 5/75	2	LOADED	102,600[a]		26,900[c]		129,500
NEW YORK 74	2	LOADED	78,850[b]			"OTHER THAN PERSONNEL" 15,312	94,162
NEW YORK 74[d]	2	LOADED	226,800			"OTHER THAN PERSONNEL" 34,824	261,624
DENVER, TRW '74	62	IDLE	600,000	1,178,000	50,000[c]	ENFORCEMENT: 548,000 DATA COLLECTION: 224,000	2,600,000 83,900/2 LANES
DENVER, TRW '74	68	LOADED	776,000	1,428,000	120,000[c]	ENFORCEMENT: 600,000 DATA COLLECTION: 224,000	3,148,000 92,600/2 LANES

a/ INCLUDES 20 % FRINGE
b/ INCLUDES 30 % FRINGE
c/ INCLUDES EQUIPMENT MAINTENANCE
d/ EMISSIONS AND SAFETY

CHART IV

RECURRING COST ESTIMATES FOR PRIVATE GARAGE SYSTEMS

DATA SOURCE	# STATIONS	ADMINISTRATION	INSPECTION	ENFORCEMENT	DATA COLLECTION	OTHER	TOTAL
EPA - OTLUP MSED	1,000	50,000[a]	2,000,000	150,000[a]			2,200,000
BATTELLE, TCP 5/75	2 LANES	33,060[a]	64,000			SUPPLIES: 2,940	100,000
RADIAN, TEXAS 6/75	3,382	179,700[a]	1,768,000		398,100	STICKERS: 1,818,900	4,164,700
DENVER, TRW 74	600	180,000[a]	2,800,000	660,000[a]	224,000[a]	OVERHEAD: 558,000	4,422,000

---

[a] COSTS BORN BY STATE; ALL OTHER COSTS BORN BY PRIVATE GARAGES PARTICIPATING IN THE INSPECTION.